THE PYRAMID AS MEMORY HYPOTHESIS

The Hill That Rose from the Waters, Made into a Pyramid — Pyramid Texts, Utterance 600

Zep Tepi Series, The Destination — Paper I
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Abstract

"…may you make this pyramid be firm for the course of eternity…" — Pyramid Texts, Utterance 601, pyramid of Merenre (Allen 2015: 219)

The Great Pyramid of Giza was called Akhet-Khufu — the Horizon of Khufu — by the people who built it. No mummy has been found in any of the three Giza pyramids, the chambers are bare, the sarcophagus in the King's Chamber was placed during construction, and the causeways of three successive reigns average 269.4°, within 0.6° of due west (Nell & Ruggles 2014). This paper proposes that these are features of a coherent design rather than anomalies: that the Giza complex is the permanent architectural encoding of the Zep Tepi cosmological system, which the preceding papers of this series trace from the Saharan pastoral tradition to the Nile Valley.

At the landscape scale, the complex is read as instantiating a four-element relational system derived from the Richat landscape: central elevation, bounded sacred space, engineered transition water and a westward processional axis. Engineered water is documented at the Khufu harbour (Younes et al. 2024) and the Ahramat Branch (Ghoneim et al. 2024); the same water–axis–elevation triad recurs at Dahshur and Abusir and, provisionally, at the sun temple of Nyuserre. Among the sites compared, full four-element integration recurs only at Angkor Wat, in the 12th century CE.

At the dimensional scale, six exterior measurements of the Great Pyramid, operated on by the Wedjat binary fractions, reach 10 of 14 registered targets (astronomical, calendrical and the golden angle) within ±0.2%, across seven proposed knowledge domains: mathematical constants; the lunar, solar, planetary and Sothic cycles; the 70-day Sirius period; and, at a separately designated lower evidential tier, Earth's scale. The correspondences were identified post hoc; a published protocol now fixes the tests. Against equal-sized subsets of the Egyptian unit-fraction, Babylonian and decimal pools, no sampled subset matches the full fourteen-target score at the baseline tolerance, but that result is sensitive to how comparators are constructed (tails 0.011 to 0.395), and the same monument scores at chance against stellar positions (5 of 31, $p = 0.54$). Sixty-fourths outperform their neighbouring grids at Giza by a margin of +5 (random-pyramid mean −1.32; $p = 0.005$), and the base of 440 royal cubits ranks within roughly the top 5 per cent of 526 candidates for the documented targets but mid-range against shadow targets. π and φ follow from the seked of 5½ palms and count as one relationship. No arithmetical test can demonstrate intent; each narrows what else the dimensions could plausibly be.

The stellar shafts are proposed to date the construction epoch and the exterior concavity, on the geometric model of Damiani (1991), to mark the equinoxes; both are proposals. Nine proposed tests and observational expectations are stated, including an original unit-specificity prediction that has failed. The argument rests on the convergence of independent lines — hydrology, genetics, archaeozoology, texts, archaeoastronomy, mathematics and comparative architecture — not on any single test.

Keywords: Giza pyramid complex; Pyramid as Memory hypothesis; Zep Tepi; Richat Structure; Shemsu Hor; Wedjat fraction system; encoded architecture; mathematical correspondences; Green Sahara pastoralism; Nile paleohydrology; Canopus alignment; precessional astronomy; cultural memory transmission; Old Kingdom Egypt; archaeoastronomy; African Humid Period

Author's Note

A note on the subtitle: it alludes to Pyramid Texts Utterance 600, in which the creator Atum rises as the benben — the primordial mound that emerged from the waters of Nun at Heliopolis (PT 600; Allen 2015: 265), the mythic image from which the pyramid's own form is traditionally derived. The phrasing here is an evocation of that utterance, not a direct quotation.

Series Context and Key Terminology

This paper is part of the **Zep Tepi Series**. It builds directly on the findings established in the four preceding papers:

- **Corridor I (Eye of the Sahara Hypothesis):** Identification of the Richat Structure as the surviving candidate origin landscape and documentation of the paleohydrological corridor.
- **Corridor II (Zep Tepi Hypothesis):** Genomic continuity from Taforalt through Takarkori to the Nile Valley, the Wedjat sky-compass, and the cattle cult tradition.
- **Corridor III (Shemsu Hor Hypothesis):** The Followers of Horus as the institutional carriers of this knowledge across the transition to the Dynastic period.
- **Phase Zero (Bridging Paper):** The Minor Step Pyramids as a coordinated territorial program encoding the Meskhetyu astronomical tradition, bridging the gap between the Shemsu Hor and Giza.

Two supplementary papers in the series bear directly on material discussed here and are referenced at the relevant points below:

- **The Sphinx Hypothesis (Supplementary to Corridor III):** A Predynastic origin framework for the Great Sphinx and the philological case for its original name Mehit, "she who restores the Wedjat" — relevant to the Sphinx-to-Second-Pyramid geometry and the Giza plateau layout discussed in this paper.
- **The Sekhmet-Heka Hypothesis (Supplementary to Corridor III):** The inversion of rationality in the Egyptian medical corpus, and the botanical and pharmacological knowledge carried along the Saharan corridor — relevant to the medical and botanical components of the knowledge architecture referenced in this paper.

The present paper asks the question the four principal papers leave open: if the Shemsu Hor carried the knowledge and Phase Zero expressed it at provincial scale, what was ultimately built when state capacity finally matched cosmological ambition?

This paper does not re-argue the findings of Papers I–III or Phase Zero. It assumes them and builds directly on them. For the full evidentiary chain — including climatic "flickering" mechanisms, isotopic and archaeozoological correlates, the Canopus orientation family in the Egyptian temple survey (about 350 temples; thirteen within 1.1° of Canopus's declination in the published tables), the genomic continuity from Taforalt to Takarkori to Nuwayrat, the institutional memory of the Shemsu Hor across fifteen centuries of king lists, and the architectural program of the Minor Step Pyramids — see the original papers.

Chronological conventions. Absolute dates in this series follow Shaw (2000) unless stated. For the First Dynasty the series follows the Bayesian radiocarbon chronology of Dee et al. (2013), which places the foundation of the state (the accession of Aha, 3218–3035 BCE at 95%) earlier than Shaw's historical scheme; this applies to the c. 3100 BCE start of the First Dynasty and Den's accession at c. 2925 BCE used in the papers. For the Naqada phases the papers quote dates from excavation reports (for example HK6, Naqada IC–IIB, c. 3800–3600 BCE); Dee et al. date the Naqada IB/IC transition to

about 3650 BCE, IIB/IIC to about 3450 BCE and IID/IIIA to about 3325 BCE, so the earliest of these conventional dates may be up to about 150 years too old. The African Humid Period is taken as c. 14,800–5,500 cal BP; some sources give a start nearer 14,500. Where the series adopts a long Khufu reign (Phase Zero, Levy 2026d), Fourth Dynasty dates after Khufu move about 26 years later (Khafre c. 2532 BCE; end of the Giza block c. 2477 BCE). Fifth- and Sixth-Dynasty dates, including the Pyramid Texts at c. 2345 BCE, stay on Shaw's scheme, which leaves an overlap of about 17 years at the Fourth/Fifth Dynasty boundary (against Shaw's Userkaf accession of 2494 BCE). The comparison of Giza with the earlier and later pyramids in this paper uses measured dimensions and relative order, not absolute dates.

Introduction

The ancient Egyptians did not call this site Giza. That name is medieval Arabic. Later Egyptian sources know its sacred geography as Rostau (rå-ståw), recorded in the New Kingdom in the name "House of Osiris, Lord of Rostau" (Hawass 2007: 391); this paper takes "the West" (Imentet) as an interpretive motif. The pyramid at its centre they called Akhet-Khufu: the Horizon of Khufu. Not the tomb. The horizon — the threshold where the sun transforms, where the mortal becomes divine, where the First Time is renewed. That name survives in the Merer Papyrus, the eyewitness logbook of an official who transported its stones (Tallet 2017). It is not a later poetic attribution. It is the construction-era designation. Imentet: the direction the memory came from. Rostau: the transformation it was built to produce. This paper argues that the architecture says the same thing.

The standard interpretation of the Giza pyramids as royal tombs is internally coherent and accounts for much of the evidence. What it does not readily account for is the specific compound of features documented here: no mummy recovered from any of the three Giza pyramids, a sarcophagus placed during construction and never removed, interior chambers without inscription, stellar shafts, the southern Queen's Chamber shaft of which was explored by Gantenbrink's Upuaut-2 in 1993, ends in a blocking stone with two copper handles, and has walls that range from smoothly polished to roughly cut (Richardson et al. 2013: 325), and three successive causeways deviating in opposed senses about the east–west axis yet averaging within a degree of due west across three reigns (Nell & Ruggles 2014; Lehner 1985). Each feature has an individual explanation. The constraint is that any viable interpretation must account for all of them simultaneously — and must do so without treating the pyramid's own documented name as incidental.

The preceding papers of this series have assembled the transmission chain that makes a different reading possible. A pastoralist population carrying the Zep Tepi cosmological system moved northeast along a documented Highland Corridor as the African Humid Period collapsed. Ancient genomes are now available from three geographically independent North African nodes (Salem et al. 2025; Lipson et al. 2025; Morez Jacobs et al. 2025), documenting a distinct North African lineage present across the region through the period in question. That lineage is anterior to the window: van de Loosdrecht et al. (2018) report Pleistocene North African genomes linking Near Eastern and sub-Saharan African ancestry, which predate the period considered here and supply the earlier population against which the continuity reported by the three studies above is measured. Salem et al. conclude that pastoralism entered this lineage by cultural diffusion rather than population replacement, and Lipson et al. document high continuity of local ancestry in the eastern Maghreb. The genetic record therefore supports the movement of practice and knowledge rather than large-scale replacement of populations — the mechanism this series proposes, and a weaker requirement than migration in the demographic sense. Their cosmological system encoded the Richat Structure as the landscape of the First Time. The Shemsu Hor are proposed here to have preserved and transmitted this knowledge across fifteen centuries of Egyptian institutional memory. The pyramid form itself was already encoded in stone at seven provincial cult centres before Khufu was born (Dreyer & Kaiser 1980; Belmonte, Shaltout & Fekri 2005). What was built at Giza in the 4th Dynasty is proposed here not to have been an invention but a culmination of a tradition whose origins are the subject of this series.

The mechanism by which cosmological knowledge survives across millennia is not conjectural — it is the subject of an established scholarly literature. Assmann (1995, 2001) distinguishes communicative memory (living within three to four generations) from cultural memory (preserved over centuries and millennia through canonical texts, ritual repetition, and institutional structures). Cultural memory of this kind operates through what Assmann calls "figures of memory" — narrative and symbolic patterns that anchor collective identity to a foundational past event. The Zep Tepi is precisely such a figure: a temporal anchor ("the First Time") that Egyptian priestly institutions returned to consistently across fifteen centuries of dynastic record. The durability of such anchors is well-documented: Australian Aboriginal oral traditions have been demonstrated to preserve accurate coastal geography from events approximately 7,000 years ago (Nunn & Reid 2016). The transmission proposed here — approximately one thousand years from the end of the African Humid Period (c. 5,500 BP) to the 4th Dynasty — falls well within the documented range of canonical cultural memory in pre-literate and proto-literate institutional contexts. The Shemsu Hor records are proposed here as the institutional expression of that preserved memory, not as proof of literal genealogical continuity.

The following table defines the four distinct types of continuity claim made in this paper and the evidence type required for each. These categories are maintained as distinct throughout; claims should be evaluated at the level appropriate to their category.

Concept	Definition	Required Evidence Type	Examples in This Paper
Symbolic continuity	Recurrence of structurally equivalent motifs across time	Iconographic and architectural parallels	Herd for the dead; mound-water motif; Wedjat geometry; Benben symbolism
Institutional continuity	Preservation of ritual systems within functioning institutions	Documentary or archaeological evidence of institutional succession	Pyramid priesthood records; Shemsu Hor title in Turin Canon and Tombos Stela
Cultural memory	Cosmological framework transmitted as shared social knowledge across generations	Canonical textual codification of earlier traditions	Edfu Building Texts encoding Zep Tepi; Pyramid Texts preserving stellar destiny theology
Historical continuity	Demonstrable biological, genealogical, or institutional lineage	Genetic, epigraphic, or archival evidence of actual succession	Salem et al. (2025) North African lineage documented across the corridor region; Van Neer et al. faunal continuity at HK6

The Subterranean Sanctuary: Rostau and the Design Template

The Westcar Papyrus (Berlin Papyrus 3033, c. 1650 BCE) records a primary source tradition that Khufu was not designing his pyramid without a template. The text states that Khufu spent time seeking the number of the secret chambers in the sanctuary of Thoth in order to make something similar for his own pyramid (Blackman 1988; Parkinson 1997). The magician Djedi knows where this number is recorded — in a flint chest in the room called the Inventory at Heliopolis — but cannot deliver it. The number is never recovered within the narrative. What the papyrus establishes, within the narrative, is Khufu's intent: the story portrays the Great Pyramid's chamber design as to be modelled on a pre-existing sacred architectural template, and the numerical count of its hidden chambers as the design specification Khufu sought. It does not independently establish what the historical builders did.

Hawass (2007: 391) records that the Giza plateau was known in the New Kingdom as pr wsir nb rstaw — "the House of Osiris, Lord of Rostau". This later designation supports the association of Giza with Osirian sacred geography, but does not independently date that association or establish that the Osiris

Shaft preceded the pyramids; the proposed earlier sanctuary remains the interpretation tested in Prediction 9. That complex — the multi-level subterranean structure now called the Osiris Shaft, located beneath Khafre's causeway — is the only structure at Giza architecturally parallel to the Abydos Osireion, a parallel Hawass confirmed directly, calling it "the Osirion of Giza" (Hawass 2007). Surface luminescence dating of two sarcophagi on the shaft's second underground level — sample OT1 from a dacite sarcophagus and OT2 from a granite one — yields ages of 2930 ± 600 BCE and 2870 ± 570 BCE (Liritzis and Vafiadou 2015, Table 1). The authors interpret these results as compatible with a Fourth Dynasty age, in contradiction to the sixteenth- or early seventh-century BCE date indicated by the archaeological finds inside, and suggest early construction followed by later reuse to explain the difference (Liritzis and Vafiadou 2015: 148). Their Table 1 and Figure 2 place the two samples on the second level, whereas their discussion refers to a third-level dacitic sarcophagus; that discrepancy is not resolved here. The central estimates precede conventional Fourth Dynasty dates, while their broad quoted uncertainties overlap that period.

These measurements support early surface histories of the sarcophagi under the study's analytical assumptions; associating the dated event with emplacement in the present shaft requires a further contextual argument. If that association is established, the shaft must already have existed at emplacement. An older surface history retained through later relocation would not establish the same chronological bound, just as a younger signal caused by reopening would not automatically date first construction. The two results therefore warrant investigation of an early phase without independently resolving when the shaft was cut. No pharaoh inscribed his name on the structure as builder, inconsistent with a new royal project. Stadelmann is cited for the view that Khafre's causeway was built to conform to a pre-existing feature at its location (Stadelmann 1991; attribution not independently checked here). Hawass (2007: 390) instead inferred a Sixth-Dynasty origin from the earliest recovered pottery, potsherds of that date found in Shaft C.

Neither that inference nor the earlier sarcophagus surface ages independently dates first cutting; the pre-causeway interpretation proposed here requires direct construction-context evidence. A pre-existing shaft is proposed here as one explanation of the spatial relationship; this paper does not supply a structural analysis excluding later excavation. The Shetayet of Sokar — the god's hidden tomb-shrine, located at Rosetau and understood in Egyptology as the Lower Egyptian counterpart of the Osiris tomb at Abydos (Edwards 1986) — anchors the plateau's underworld geography, Sokar being 'lord of Rosetau'. The structural argument advanced here is that the Osiris Shaft complex was the defining sacred feature of that Rosetau, not a later addition to it. This paper advances as a structured open question — and as Prediction 9 — that the Osiris Shaft complex is proposed here as the pre-existing sanctuary that gave Rostau its name, and the most plausible candidate for the architectural template the Westcar Papyrus narrative records Khufu seeking.

This paper advances one central hypothesis: that the Giza pyramid complex constitutes a deliberate and permanent encoding of the Zep Tepi cosmological system — the origin landscape, stellar grammar, and cosmological memory of a Saharan pastoral tradition transmitted through the documented corridor established in the preceding papers of this series. All subsidiary arguments — the dimensional correspondences, the institutional transmission chain, the water-cosmological integration, and the stellar orientation system — are proposed as supporting evidence for this central claim. They are advanced in hierarchical order: the landscape-scale and hydrological evidence constitutes the strongest evidential tier; the mathematical encoding claims are the most novel and the most in need of independent verification. A reader who accepts only the landscape-scale tier and remains agnostic about the mathematical tier still has access to the paper's primary argument.

Methodologically, this paper operates as a cumulative probabilistic convergence model rather than a singular historical reconstruction. No single line of evidence presented here establishes the hypothesis independently. What the framework proposes is that the independent convergence of genomic migration data, paleohydrological reconstruction, zooarchaeological assemblage analysis, archaeoastronomical measurement, architectural correspondence, and textual transmission

scholarship — across research programmes designed for entirely different purposes — on the same geographic corridor, temporal window, and cosmological grammar constitutes a probabilistically meaningful pattern. The hypothesis strengthens with each additional independent confirmation, and would weaken materially if independent streams were found to contradict rather than reinforce each other. This is the epistemological structure of consilience-based historical reconstruction, as formalised by Whewell (1840) and operationalised in contemporary landscape archaeology and archaeoastronomy.

This paper documents what that culmination encodes. At the landscape scale, the Giza complex instantiates the four-element relational system derived from the Richat origin landscape — central elevation, bounded sacred space, engineered transition water, and a western processional axis — confirmed across hydrology (Sheisha et al. 2022; Younes et al. 2024), archaeoastronomy (Belmonte & Lull 2023), and survey data (Nell & Ruggles 2014). At the dimensional scale, the Great Pyramid's exterior measurements show correspondences — proposed in this hypothesis to reflect deliberate encoding through the Wedjat binary fraction system — across seven independent knowledge domains, of which eleven individual correspondences are set out with their complete arithmetic in Table 3 — a count of correspondences, not to be confused with the ten of fourteen target hits reported in the Monte Carlo analysis. Their coverage of Old Kingdom astronomical knowledge — planetary, lunar, solar, and Sirius-calendar — is the core claim of this section. These two registers are one argument: a permanent architectural solution to the specific problem created when a cosmological system loses its geographical anchor. The paper establishes the evidence, tests it against nine comparative landscapes, and states nine falsifiable predictions.

A note on these two registers and their evidentiary standards: the landscape-scale claims — relational geometry, directional orientation, water-feature correspondence, and comparative architecture — are supported by independent satellite surveys, hydrological reconstruction, archaeoastronomical measurement, and cross-disciplinary confirmation. They constitute the primary evidential core of this hypothesis. The dimensional-scale claims — mathematical correspondences through the Wedjat fraction system — are supported by arithmetic calculation, a fraction-system control test, and the Monte Carlo analysis reported below; they nonetheless remain the more novel register and the one most in need of independent replication. Throughout this paper, these two registers are maintained as distinct: landscape-scale observations are described in terms of correspondence and confirmation; dimensional-scale observations are explicitly framed as proposed and pending independent verification. A shift in register is always explicitly marked in the text; claims should be evaluated at the evidentiary level appropriate to the register in which they appear.

The argument does not end at Giza. The same cosmological grammar — central island, encircling water, bounded sacred space, east-west axis — was reinstated in megalithic stone at Abydos, at the primary Shemsu Hor institutional site, some 580 years after Giza on the central estimate: Liritzis and Vafiadou (2015) report a granite-surface luminescence age of 1980 ± 160 BCE for the Osireion, against c. 2580–2540 BCE for the Great Pyramid. That is a reported surface result with its own uncertainty, not by itself a demonstrated construction date, and its association with the dated event is conditional. That structure, the Osireion, stands as a late architectural expression of the Nun cosmological tradition; it is not examined in detail here.

A note on evidentiary categories: the evidentiary categories used in this paper are hierarchical rather than equivalent. Peer-reviewed archaeological and archaeometric findings constitute the paper's foundational evidentiary layer. Established interpretive scholarship is treated as supporting analysis. Later textual traditions with acknowledged temporal distance are used as contextual or corroborative material only. Original observations introduced in this paper are explicitly identified as hypothesis-generating rather than established findings.

The Anomaly: What the Evidence Demands We Explain

A note to readers: This paper is a continuation of the Zep Tepi Series. It does not re-establish the core findings of The Corridor Series: that the Richat Structure is the sole surviving candidate for the Saharan origin landscape under defined constraints (Corridor I); that the Zep Tepi cosmological system originated in the Green Sahara and was transmitted via the Wedjat sky-compass and the herd for the dead (Corridor II); and that the Shemsu Hor preserved this knowledge across fifteen centuries of Egyptian memory (Corridor III). This paper is the first of The Destination Series. Readers unfamiliar with these foundations should consult those papers first. The present paper asks: given all that, what was built at Giza?

No Mummies Have Been Found in the Giza Pyramids

Mainstream Egyptology has long interpreted the Giza pyramids as royal tombs, pointing to the presence of sarcophagi, mortuary temples, and later textual traditions. However, the absence of primary burial equipment — mummies, canopic jars, grave goods, or identifying inscriptions — in the original chambers of all three Giza pyramids is striking. This paper does not dispute that the pyramids served a funerary function. It argues that the design priorities — particularly the engineered water, western axis, bare walls, and stellar alignments — are better explained by a cosmological purpose within which the king's transformation was nested. The two readings are complementary at different interpretive scales.

No mummy has ever been found inside any of the three great Giza pyramids. The King's Chamber in the Great Pyramid of Khufu contains a lidless granite sarcophagus — too wide to have been brought through the ascending passage, meaning it was placed during construction — but it is empty. No mummy, no canopic jars, no burial goods, no identifying inscriptions were present when Caliph al-Ma'mun breached the pyramid in approximately 820 CE.

Fragmentary bone material of uncertain date has been found in the burial chambers of the other two Giza pyramids. When Giovanni Belzoni entered the burial chamber of Khafre's pyramid in 1818, he found the granite sarcophagus half open, its lid broken at the side and its interior holding earth and stones; he noticed bones among the rubbish the next day, and reports that those sent to London proved to be the bones of a bull (Belzoni 1820: 270–276). Richard William Howard Vyse describes a basalt sarcophagus in Menkaure's pyramid as entirely empty and finely carved in compartments; it was shipped from Alexandria in the autumn of 1838 on a vessel that was never heard of again (Vyse 1840, II: 84). In the large entrance-room rubbish he also found fragments of the top of a mummy-case bearing the cartouche of Menkahre, with part of a skeleton wrapped in coarse woollen cloth (Vyse 1840, II: 86); H. Raven's letter judged that the coffin appeared to have been brought to that spot and unpacked there. The date of these remains is not established by Vyse's account. No intact burial, no identifiable royal remains, and no securely identified intact primary royal burial assemblage have been recovered from any of the three Giza pyramids.

The Amherst papyrus (Peet 1930: 45–51) records the confession of thieves involved in the robbery of the tomb of Sobekemsaf II in the 20th Dynasty, and describes the plundering of a king’s and queen’s coffins, the taking of their gold and the burning of their inner coffins (Peet 1930: 48–49). Peet tentatively identifies the unnamed confessor as Amenpnufer; the complementary Leopold II fragment was identified later. This is some fourteen centuries after Khufu’s death. Royal tomb robbery in that period is therefore documented, and it accounts for the absence of reusable valuables (gold, jewellery, canopic equipment) from later Theban royal burials. It does not account for the total absence of any such traces in the Giza primary chambers: the contrast with later pyramids such as Unas and Teti, where Pyramid Texts and fragmentary human remains are both reported (de Trafford 2005: 185), is retained as a comparative observation, but the cited robbery account cannot determine whether Giza’s missing organic remains and portable equipment reflect original absence or later removal.

The sarcophagus in Khufu's King's Chamber survives as a lidless, empty granite vessel, with breakage noted by Petrie (1883: §§58–59). No burning or ash deposits are recorded in the sources cited here. Had robbers burned a body inside the sarcophagus, residue would be expected; none is recorded in the sources cited here, though absence of a record is weak evidence. This does not exclude in-situ destruction, and it does not exclude the more common practice of removing a body intact to strip it elsewhere, which would leave no trace. The residue-free, though broken, sarcophagus is therefore consistent with robbery as much as with non-burial, and is offered as one observation among several rather than as decisive on its own. However, the confession does not explain:

Hawass himself has publicly stated his belief that "Khufu's real burial chamber is still hidden inside the pyramid" (Piers Morgan Uncensored, 15 May 2026) — reported here as Hawass's stated belief in a still-hidden chamber; this does not itself dispute a funerary interpretation. This is corroborated by the peer-reviewed scanning record itself: the discovery of the Big Void (Morishima et al. 2017, Nature), the North Face Corridor (Procureur et al. 2023, Nature Communications), and the Menkaure voids (Helal et al. 2025, NDT & E International) confirm that the pyramid's interior geometry is not fully mapped. Hawass's November 2025 announcement of a 30-metre sealed corridor (Egypt Independent, 9 November 2025), pending peer-reviewed publication, is noted here as an unverified report and carries no weight in the argument; the observation that undiscovered internal features may yet alter the interpretive landscape rests on the peer-reviewed scanning record above.

1. **The sarcophagus:** The granite sarcophagus in Khufu's King's Chamber is too wide for the passages, meaning it was placed during construction and never extracted. It is empty.

2. **The structural design:** The ascending passage is closed by granite plug blocks filling some 15 feet of its lower part (Petrie 1883, §38). The sources cited here report no evidence that the ascending passage, Grand Gallery or relieving chambers were ever resealed after being reopened; this observation does not distinguish an originally empty monument from one that was occupied and later robbed.

3. **The absence of Pyramid Texts:** Later pyramids (Unas, Teti) preserve fragments; Giza preserves nothing — even from secondary disturbances.

4. **The bare walls:** Petrie (1883, §55) records working traces on the King's Chamber walls: the remains of 15 bosses on the lowest course of granite blocks, grinding around them, and a drafted line across the large granite block over the doorway. These are construction traces, not decoration.

Robbery explains missing mummies. It does not explain the architectural design logic.

What the Egyptians Themselves Said: The Herdsmen and Shepherd Traditions

Herodotus (mid-fifth century BCE) recorded that his Egyptian priestly sources consistently placed Khufu's body elsewhere: "**in a place under the earth, on an island surrounded by water drawn from the Nile**" (Herodotus, *Histories* II.124). He also reported that the Egyptians of his time refused to speak the names of Khufu and Khafre — instead calling the pyramids after "the shepherd Philitis, who then pastured his flocks in this place" (II.128). Diodorus Siculus (c. 60 BCE) records different traditions: that although two kings built pyramids to serve as their tombs, neither was buried in them, each having ordered his kinsmen to bury him secretly in an unmarked place (Bibliotheca Historica I.64.4–6), and that others attributed the pyramids to other named kings (I.64.13) — not to herdsmen. The pastoral attribution therefore rests on Herodotus alone among these two authors; they preserve different traditions and are not two independent witnesses to one pastoral-builder statement. Identifying the pastoral memory with Saharan pastoralists is this series' hypothesis, not one made by either Greek author. As documented in Corridor III of this series, the Shemsu Hor were the cultural memory of Saharan pastoralists who arrived in Egypt from the west during the predynastic period (Corridor III, Levy 2026c).

A note on the Herodotus ‘island surrounded by water’ passage: mainstream Egyptology reads this as describing the pyramid’s position — elevated above the Nile floodplain, approached by water via the Khufu Branch canal (Sheisha et al. 2022). That reading encounters a difficulty the text itself poses: the passage specifies a place “**under the earth**”. The Great Pyramid is not under the earth. The Osiris Shaft is. Level 3 of the Osiris Shaft — approximately thirty metres below the plateau surface — features a central island permanently surrounded by a water channel fed by the Nile water table: precisely “**under the earth, on an island surrounded by water drawn from the Nile**.” Hawass identified this chamber as the symbolic Osirian burial at Giza — the Osirion of Giza — and it is the structure this paper identifies as the pre-existing Rostau sanctuary beneath the plateau. The most literal reading of Herodotus is that his Egyptian priestly sources were directing him to the underground sanctuary, not to the pyramid above it: in Egyptian tradition, Khufu’s sacred identity resided in his transformation as Osiris in the subterranean chamber below, not in the stone structure above.

The mainstream reading and the present reading are not mutually exclusive — but the Osiris Shaft satisfies the passage’s literal description with a precision the pyramid’s above-ground position cannot match. A further philological note strengthens this reading: the Godley Loeb translation of Herodotus II.127 (the immediately adjacent passage, which contrasts Khafre’s pyramid with Khufu’s) reads: “the river comes in through a built passage and encircles an island, in which, they say, Cheops himself lies” — a description that, read carefully, locates Khufu’s burial within a water-circled island, described in that contrast with Khafre’s pyramid, not in the pyramid above. Identifying that island with the Osiris Shaft is this paper’s proposal; Herodotus gives no such location. The two water-feature passages in Herodotus — the underground chambers surrounded by water (II.124–126) and the canal-fed island where Kheops lies, mentioned in II.127 in contrast with Khephren’s pyramid, which has neither — both concern Khufu’s pyramid and are not contradictory; they are consistent with the reading advanced here that the Osiris Shaft’s subterranean Nun-island and the surface hydraulic infrastructure constitute a single integrated cosmological landscape.

A fourth witness to this tradition comes from within Egyptian literary culture itself. The Westcar Papyrus (P. Berlin 3033, c. 1650 BCE), set at Khufu’s court, associates the king’s pyramid-building ambitions with hidden sacred knowledge — specifically, the secret chambers of Thoth. In a key passage, the sage Djedi tells Khufu about the number of hidden rooms in the sanctuary of Thoth, and the text connects this esoteric knowledge to Khufu’s building ambitions, with some scholars reading the language as carrying resonances of the king’s desire to create something comparable to the horizon (Blackman 1988; noting that the text’s primary register is literary entertainment and this reading is not universal). The resonance, where present, is striking: an Egyptian literary text, composed roughly a millennium after Khufu’s reign, associates the king’s pyramid-building ambitions with esoteric knowledge and cosmic aspiration, without excluding a funerary purpose — echoing the monument’s own attested name *Akhet-Khufu* in the contemporary Merer Papyrus (Tallet 2017). The Westcar Papyrus was composed roughly a millennium after Khufu’s reign, yet it preserves a cultural memory in which the pyramid is inseparable from esoteric knowledge and cosmic aspiration, without excluding a funerary purpose. Taken together, the Merer Papyrus, Herodotus, Diodorus Siculus, and the Westcar Papyrus represent four ancient sources of distinct type, provenance, and evidentiary weight — from contemporary administrative record to Greek historiography to Egyptian literary tradition, composed across a span of roughly two and a half millennia — none of which describes Khufu’s burial in the Great Pyramid. This convergence is noted as corroborative context, not as proof of the cosmological hypothesis; the sources differ too greatly in reliability and intent to be treated as a unified evidential body.

No Hieroglyphs Inside the 4th Dynasty Pyramids

The Egyptians were obsessive documenters. Yet the three Great Pyramids at Giza have almost completely bare interiors. Not a single dedicatory inscription, spell, or caption. The text recorded inside the Great Pyramid consists of construction marks: Khufu’s cartouche occurs as a quarry mark on the building stones (Petrie 1883) and, according to Richardson et al. (2013: 346), red ochre mason’s

marks, possibly hieratic characters, in the southern Queen's Chamber shaft between its first and second blocking stones. None is a dedicatory inscription.

This absence is anomalous for a culture that inscribed its tombs and temples exhaustively, yet it is what a mnemonic reading predicts. In the comparative framework of Kelly (2015), a monument built to encode knowledge does so structurally — in form, proportion, and alignment — rather than in text: the information is carried by the architecture itself rather than written upon it. On that reading the bare interiors are not an absence to be explained away but the expected signature of a structure whose content is encoded in its dimensions.

The argument advanced here is not that the Giza pyramids had no funerary role. The king's burial and apotheosis were real and ritually significant. The claim is that the primary design logic — the bare walls, the engineered water, the western axis, the stellar alignments, the absence of canopic equipment — is better explained as a cosmological monument than as a tomb that happens to have anomalous features. The two purposes are nested, not opposed. **A more precise formulation is that the pyramids' design is not optimized for burial** — the absence of canopic equipment, identifying inscriptions, and burial goods suggests that preservation of the body was not the primary architectural driver.

The content of the 5th Dynasty inscriptions confirms this reading. Utterance 213, inscribed on the south wall of the Unas pyramid's burial chamber (c. 2375–2345 BCE), opens the entire inscription program with a formula that defines its purpose: *'O Unas, you have not gone dead, you have gone alive to sit on the throne of Osiris.'* Not burial — transformation. The pyramid texts do not describe a dead king lying in a tomb. They describe a living king moving through a cosmological sequence. This paper proposes that an earlier ritual sequence was expressed architecturally before its surviving inscription; the absence of captions does not by itself establish either full contemporary understanding or later memory loss. The Pyramid Texts may be the verbal transcription of an architectural reality that preceded them by two centuries.

One structural observation is worth registering here for future investigation: the Great Pyramid contains three main chambers arranged one above another (Subterranean, Queen's, King's), though not on a single vertical line: Petrie places the King's Chamber walls about 8.4 m (north wall) to 13.6 m (south wall) south of the pyramid's centre (1883, §55). This ascending vertical arrangement — with chambers rising progressively from bedrock through the pyramid's mass to about 43 m above the base — has no close parallel in any other Old Kingdom pyramid in the standard comparative record. Djoser's Step Pyramid presents a vertical arrangement of subterranean chambers below the pyramid but does not extend this progression into the pyramid mass above bedrock level; the ascending arrangement of internal chambers within the body of the structure itself is specific to the Great Pyramid. By contrast, standard Old Kingdom pyramid design places the burial chamber below the pyramid in the bedrock (Lehner 1997, pp. 108–113). The Bent Pyramid of Sneferu contains an upper chamber within the pyramid's masonry body (entered from the western side of the pyramid), which might appear to parallel the Great Pyramid's ascending arrangement. How that chamber and the Bent Pyramid's double slope should be explained is disputed: the usual account treats the cracks and cedar beams in its inner rooms as responses to structural problems, while Nuzzolo (2015) re-examines the evidence and argues that the form may be an intentional architectural framework, reporting that Maragioglio and Rinaldi doubted that the beams were shoring. The Bent Pyramid is therefore not used here as a settled structural accident. Whatever its explanation, it does not present the Great Pyramid's three tiers (Subterranean in bedrock, Queen's in the lower body, King's in the upper body, spanning the height from geological base to the upper body of the structure), and the sources cited here record no earlier pyramid with that sequence. Belmonte and Magli (2015: 174, 193) read Sneferu's two Dahshur pyramids as one unified project with a paired symbolic content. The ascending three-chamber arrangement is an anomaly that requires explanation within any model of the pyramid's function.

The Bare Walls: Why the Great Pyramid Has No Hieroglyphs

The standard Egyptological explanation for the bare interior is temporal: the tradition of decorating pyramid interiors with Pyramid Texts began with Unas (c. 2375–2345 BCE), two centuries after Khufu. This is accurate but does not explain why the tradition began when it did.

This paper proposes a complementary explanation: the Pyramid Texts appear in the 5th Dynasty because the living understanding of the cosmological system was beginning to fade. The Shemsu Hor period ended at approximately 3100 BCE. The Great Pyramid was built roughly 500 years later — about 20 generations. At that point, the cosmological tradition was still institutionally alive. The form of the pyramid was readable. No caption was necessary.

By the 5th Dynasty (c. 2494–2345 BCE), another 200 years had elapsed. The direct embodied understanding that made architectural form self-explanatory may have been attenuating. The Pyramid Texts are the verbal caption for an image that had once been self-evident.

The linguistic and architectural evidence supporting this temporal layering is well established in the Egyptological literature. James P. Allen, in the introduction to his standard translation of the Pyramid Texts, documents two convergent lines of evidence for the texts' antiquity relative to their 5th Dynasty inscription. First, "most of the Pyramid Texts are undoubtedly older. With few exceptions, their grammar is that of a stage of the language older than that which began to appear in secular inscriptions at least fifty years earlier." The texts were not composed fresh for Unas; they were copied from older sources preserving an already-archaic linguistic register. Second, "the architecture of the pyramid chambers that they reflect ... came into use at the end of the Fourth Dynasty, more than a hundred years before Unis's time" (Allen 2015: 4). Morales (2016) documents the broader transmission mechanism: in his account, oral recitation was first transcribed on papyri as aide-mémoire for ritual performance, and the process culminated in the inscription of the sealed crypt of Wenis (Unas) around 2345 BCE (Morales 2016, abstract; cf. Allen 2015: 4). Allen (2015: 4) states that most of the Pyramid Texts are older than their first attestation, that their grammar is older than contemporary secular inscriptions, and that the pyramid-chamber architecture they reflect came into use at the end of the Fourth Dynasty. Extending that tradition back to Khufu's era is an interpretation of this paper.

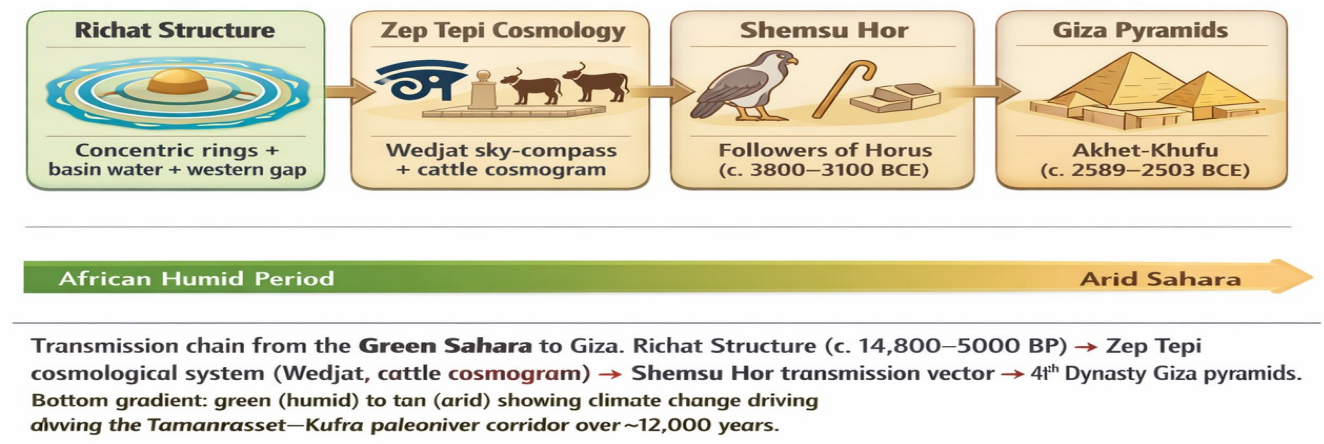
The Abusir Papyri (24th century BCE, Fifth Dynasty) document that pyramid complexes were functioning cult centers with priests and offering rosters (Posener-Kriéger 1976). The Fifth Dynasty wrote extensive administrative texts about pyramid cults. The Fourth Dynasty did not write inside pyramids because the living tradition of embodied cosmological knowledge may have made text unnecessary — in this reading, the stone itself was the statement.

A further line of evidence deepens this temporal picture. Manetho, the Egyptian priest-historian who compiled the *Aegyptiaca* in the early 3rd century BCE from native temple records, places pyramid construction in the First Dynasty under King Vavenephis: "Vavenephis, for 42 years. In his time famine seized the land. He reared pyramids near the town of Cho" (Waddell 1940, Loeb Classical Library, p. 33). The site identified as Cho — Sakkara — was, as the Loeb edition's own note records, confirmed by W.B. Emery's excavations of 1935—1938, which uncovered First Dynasty tombs containing stepped-brick pyramid constructions (Waddell 1940, p. 33 n. 3). This places the origins of the pyramid form approximately four centuries before Khufu, around 3000 BCE. Direct archaeological corroboration comes from the seven Minor Step Pyramids of the late 3rd and early 4th Dynasty at provincial centers across Upper Egypt — Elephantine, Naga el-Ghoneimiya (Edfu South), el-Kula at Hierakonpolis, Naqada, Sinki at Abydos, Zawiet el-Meitin, and Seila — identified as a coherent group by Dreyer and Kaiser (1980) and astronomically analyzed by Belmonte (2005). Four of these structures form a cardinal-or-quarter-cardinal group that Belmonte, Shaltout and Fekri (2005: 13) interpret astronomically, alongside the relation of most of the group to the course of the Nile (Levy 2026d, Phase Zero). The pyramid form and its stellar orientation procedures were therefore already established at provincial cult centres by the time Khufu's architects laid out Akhet-Khufu — on the

Minor Step Pyramids' own late Third to early Fourth Dynasty horizon, within a generation of Giza, and on Manetho's First Dynasty testimony some four centuries earlier. The 4th Dynasty monuments at Giza were not an invention but the culminating monumental expression of a tradition already ancient when Khufu was born. If the pyramid form was already centuries old, neither was the cosmological grammar it expressed a 4th Dynasty novelty. The bare walls of Khufu's chambers require no text not because the tradition had not yet developed, but because it was still fully embodied. This is precisely the pattern James Henry Breasted identified in 1912: the solar religion of the 5th Dynasty absorbed and transcribed an older stellar tradition whose living expression had been architectural, not textual (Breasted 1912). Breasted's "absorption" model was a description of a fading, not an origin — and Allen's linguistic evidence confirms that the Pyramid Texts were transcribed from material already archaic when they were first inscribed (Allen 2015: 4). On this hypothesis, the stone spoke while the tradition lived. When it began to fade, the scribes began to write.

The Predynastic Grammar (c. 3,800–3,100 BCE)

The Shemsu Hor — the Followers of Horus — are the Egyptian cultural memory of the Saharan migrants who arrived in the Nile Valley during the 3800–3100 BCE window. **This paper assumes the reader is familiar with the full evidentiary chain established in Corridor Series (Corridor III, Levy 2026c).** In summary: the Shemsu Hor occupy a non-optional structural slot in Egyptian king-list architecture across fifteen centuries. Later pharaohs cite their written annals. Ptolemaic builders cite a leather roll containing architectural plans.



Transmission chain from the **Green Sahara** to Giza. Richat Structure (c. 14,800–5000 BP) → Zep Tepi cosmological system (Wedjat, cattle cosmogram) → **Shemsu Hor** transmission vector → 4th Dynasty Giza pyramids. Bottom gradient: green (humid) to tan (arid) showing climate change driving *dlving the Tamanrasset–Kufra paleoniver corridor over ~12,000 years.*

Phase Zero: The Bull in the Sky (Levy 2026d) establishes the institutional transmission chain across the roughly 500-year window between the end of the Shemsu Hor period (c. 3100 BCE) and the construction of the Great Pyramid (c. 2580–2540 BCE), through the Minor Step Pyramid tradition, the Djoser complex, and the archaeozoological evidence for Shemsu Hor continuity documented at Hierakonpolis. That argument is not reproduced in this paper; this paper assumes its findings as established.

The External Architecture of Giza (c. 2,580–2,540 BCE)

The Akhet: Not a Tomb but a Horizon

The original Egyptian name for the Great Pyramid was *Akhet-Khufu* — 'Horizon of Khufu.' The Merer Papyrus — the eyewitness logbook of an inspector who transported stone blocks during Khufu's reign — repeatedly refers to the structure by this name, most explicitly in the dated entries of Logbook A (Tallet 2017; Tallet & Lehner 2021). The *Akhet* is the liminal zone where the sun rises and sets, where the king transforms from human to divine. It is a threshold, not a storage place for a body. Lehner's observations at the Sphinx Temple, as reported by Joyanes-Díaz et al. (2025), show the sun around

the summer solstice setting between the pyramids of Khufu and Khafre; those authors suggest that the two pyramids and the setting sun between them may have been a materialised sign for akhet, which also appears in the name Akhet Khufu.

The Pyramid Texts bear on what the name encodes. Inscribed on the antechamber walls of the Unas pyramid (c. 2375–2345 BCE), Utterance 260 has the king say, in Allen's translation, that he has *emerged today in the true form of a living akh* (Allen 2015). Not a dead king lying in a tomb — a living akh emerging. In Utterance 257 (antechamber west wall) the king declares, *I acquire the sky and split open its basin*, and says that when he sets in the west those of the Duat follow him (Allen 2015). The pyramid's name — Akhet-Khufu, the place where Khufu takes the Horizon — is read here as naming the event these inscriptions describe, and the Pyramid Texts as a verbal counterpart of what the 4th Dynasty architecture was built to produce. That is an interpretation: the Texts are of Fifth-Dynasty date and do not describe Giza.

The Benben and the Primordial Mound

Egyptian creation mythology consistently describes the origin of the world as a pyramid-shaped mound — the Benben — rising from the primordial waters of Nun. Pyramid Texts Utterance 600 addresses Atum directly: "Atum Beetle! You became high, as the hill; you rose as the benben in the Benben Compound in Heliopolis" (PT 600; Allen 2015: 265). The pyramid form is this cosmology made architectural.

That the pyramid was understood as the physical vehicle of this ascent — and not merely its symbol — is the reading proposed here, drawing on the Pyramid Texts of the Unas pyramid (c. 2375–2345 BCE). Utterance 267, on the south wall of the antechamber, is translated by Allen (2015) as *A footpath to the sky is laid down for me*, on which the king goes up on the smoke of a great censing, flying as a bird and alighting as a beetle in the empty seat in the Sun's boat. The text speaks of a footpath to the sky; it does not say that a built structure is that path. The proposal that the architecture and the ascent were conceived together is therefore an interpretation of the text, not something the inscription itself states.

> ⚠️ **CRITICAL CAVEAT ON TEXTUAL SOURCES:** The textual sources cited here (Pyramid Texts, Coffin Texts, Edfu Building Texts, Dendera inscriptions) postdate the 4th Dynasty by centuries to millennia. They are **not** treated as direct historical records of Old Kingdom belief. Rather, they are treated as later codifications of cosmological concepts that the Egyptians themselves attributed to earlier periods — a standard method in Egyptology (Assmann 2001; Hornung 1996). This temporal distance is acknowledged as a limitation.

The following table makes explicit the chronological tiers of textual evidence used in this paper and the evidentiary weight assigned to each. Old Kingdom sources are given primary evidential status; Ptolemaic and later sources are used interpretively, with the temporal distance explicitly noted as a caveat throughout.

Source Layer	Period	Example Sources	Evidentiary Weight	Use in This Paper
Old Kingdom	c. 2686–2181 BCE	Pyramid Texts; Merer Papyrus	Primary — contemporaneous	Stellar theology; construction context; royal name
Middle Kingdom	c. 2055–1650 BCE	Coffin Texts; Westcar Papyrus	Secondary — c. 500 years after	Design template tradition; Khufu seeking plans
New Kingdom	c. 1550–1070 BCE	Book of the Dead; Ramesside sources	Secondary — c. 1000 years after	Cosmological continuity evidence
Late/ Ptolemaic	664–30 BCE	Edfu Building Texts; Dendera	Interpretive — c. 2000 years after	Zep Tepi codification (explicitly caveated)

Source Layer	Period	Example Sources	Evidentiary Weight	Use in This Paper
Graeco-Roman	mid-5th c. BCE–4th c. CE	Herodotus; Diodorus; Manetho	Late interpretive — memory residue	Corroborative; no independent architectural value
Medieval Arabic	9th–14th CE	Al-Maqrizi; Surid traditions	Memory residue only	Cultural echo; explicitly lowest evidentiary weight

The Zep Tepi Cosmology and the Green Sahara

This paper proposes that the Zep Tepi cosmological system originated in the Green Sahara and was carried to the Nile Valley by pastoralists displaced by the end of the African Humid Period. **This paper assumes the reader is familiar with the full evidentiary chain established in Corridor I and II (Levy 2026a, 2026b).** In summary: Corridor I documents the Highland Corridor of elevated massifs and plateaus (Tassili n'Ajjer, Tadrart Acacus/Takarkori, Messak Settafet, Gilf Kebir) — supplemented by the Kufra paleoriver system as an eastern paleohydrological segment — as the primary migration route, identifies the Richat Structure as the probable landscape encoded as the primordial mound, and provides a 25-element testing protocol. Corridor II establishes the genomic continuity of the Saharan pastoralist lineage and documents the Wedjat sky-compass.

The identification of Richat as the specific origin landscape rests on a conjunction of three relatively rare characteristics: (1) concentric ring geometry — nested circular boundaries around a central elevation, uncommon in natural landscapes and preserved in the Zep Tepi cosmology as concentric sacred space; (2) water in the ring valley around the mound — spring-fed wadis flowing in both directions around the outer depression from a north-western source, with temporary pools (Sao et al. 2008: 5, 8; Giresse et al. 2012: 18–20) — matching the 'island surrounded by water' description in Herodotus and the Nun cosmology; and (3) human presence at the structure itself during the Green Sahara window — supported by a radiocarbon date on ash from a site at the Richat, 5093 ± 140 BP, about 4245–3633 BCE once calibrated (DaK-66; Calvocoressi & David 1979: 8, 24), by the excavators' statement that the outer-valley waters drew Neolithic people (Giresse et al. 2012: 23), and by rock art with elephants at Tililit (Lluch & Philip 2003: 95–96), in the outer-ring valley (Sao et al. 2008: 4), together with much older Acheulean tools, and by the three prehistoric sites Monod (1975) records within the structure itself.

The elimination analysis is set out in full in Corridor I and extended in Corridor II (Levy 2026a, Section 3; Levy 2026b). Twenty-eight Saharan formations have now been evaluated against four criteria fixed in advance: sufficient physical scale to sustain a population across generations; independently documented Holocene water at the structure itself rather than merely in the surrounding region; documented physical evidence of human presence at the structure during that window; and a central elevation rising from that water. Twenty-seven fail at least one. Ten of those assessed are impact craters or candidate impact structures predating the Green Sahara, from about 1.6 million years old (Tenoumer, 1.57 ± 0.14 Ma by 40Ar/39Ar: Schultze et al. 2016; Aouelloul, 3.1 Ma: Koeberl et al. 1998) to ages bounded only as younger than 120 or 345 million years (Oasis: van Gasselt et al. 2017). Talemzane and Amguid are also in this set (Lamali et al. 2016; Lambert et al. 1980; Sighinolfi et al. 2020); an impact origin is not established beyond dispute for either, since Lamali et al. (2016) retain a dissolved diapir as an alternative at Talemzane and Sighinolfi et al. (2020) do not confirm an impact origin at Amguid, and nothing in the argument depends on that status, since both are far older than the Green Sahara either way. The African impact record is reviewed by Reimold & Koeberl (2014), and two of the Chad structures in this set, Aorounga and Gweni Fada, are characterised by Koeberl et al. 2005. The massifs and plateaus — Tassili n'Ajjer, the Tadrart Acacus, the Gilf Kebir — have documented regional occupation but are ridges and tablelands rather than a unified mound within a water-retaining basin, and Nabta Playa is a basin, the geometric inverse of a mound. The most

instructive failure is Semsiyat Dome: it shares the Richat's exact geological origin and lies only 45 kilometres away, yet at roughly a tenth of the diameter it could never have sustained a lasting population. Scale, not ring morphology alone, does real work in the elimination. Only the Richat passes all four, and it alone advances to the seven-criteria textual filter applied in Corridor II, which it also passes. The hypothesis does not depend on the Richat specifically, but on a western Saharan source fitting the descriptors; the Richat is the only currently known candidate that fits all of them.

The Relational System: A Four-Element Framework

The hypothesis proposes that Giza instantiates a specific four-element relational system derived from the Richat landscape. Each element is defined below with measurable criteria.

Element	Definition	Richat Expression	Giza Expression	Testable Criterion
Central Elevation	A raised focal point at the geometric center	Central uplift (~80m above inner ring)	Khufu pyramid apex (146.6m)	Central structure dominant; largest single monument at site
Bounded Sacred Space	Enclosing circular/rectangular boundary	5+ concentric cuestas; enclosure walls	Mortuary temple + valley temple + enclosure wall	Boundary walls documented archaeologically
Transition Water	Water surrounding/approaching the mound	Paleolakes in annular depressions during Green Sahara	Ahramat Nile Branch; artificial harbor channels (Ghoneim et al. 2024)	Hydrological reconstruction confirms water proximity at construction epoch
Processional Axis	Directional path from water to monument	Wadi Bamouéré draining west from the outer ring; Wadi Akerdil east (Sao et al. 2008)	Causeway + valley temple approach from Nile	Causeway axis oriented to Nile; western alignment documented

This operationalization distinguishes the hypothesis from generic "sacred landscape" claims. Each element is independently verifiable at both the origin (Richat) and destination (Giza).

Every major physical element of the Giza pyramid complex corresponds to an element of the Zep Tepi cosmological system.

Table 1: Architectural Homology with Zep Tepi Cosmological Template

Zep Tepi Element	Physical Expression at Giza	Evidence / Source
Primordial mound (Benben) rising from waters	The pyramid itself — a mound rising to a pyramidal apex	Pyramid Texts Utterances 600, 587

Zep Tepi Element	Physical Expression at Giza	Evidence / Source
Primordial waters of Nun	Khufu Branch canal (Sheisha et al. 2022) and Ahramat Branch (Ghoneim et al. 2024); Khufu harbour basin (Younes et al. 2024)	Sheisha et al. 2022 PNAS; Ghoneim et al. 2024; Younes et al. 2024
Concentric rings	Enclosure walls (peribolos) surrounding the sacred precinct	Physical remains, Giza Plateau Mapping Project
Western origin — the homeland	Causeway directed westward toward the desert	Egyptian cosmological association of west with origin
Pyramidal form as 'first solid land'	Giza plateau — a natural limestone spur chosen because it was already elevated	Geological survey; Lehner 1997
Solar axis — where first sun touched the mound	Alignment to true north achieved via meridian transit of Meskhetyu (Bull's Foreleg / Ursa Major); within about 4 arc minutes	Belmonte 2001 (Meskhetyu pairing); Dash 2017; Spence 2000 (Kochab–Mizar pairing)

Causeway Orientations: A Consistent Western Pattern

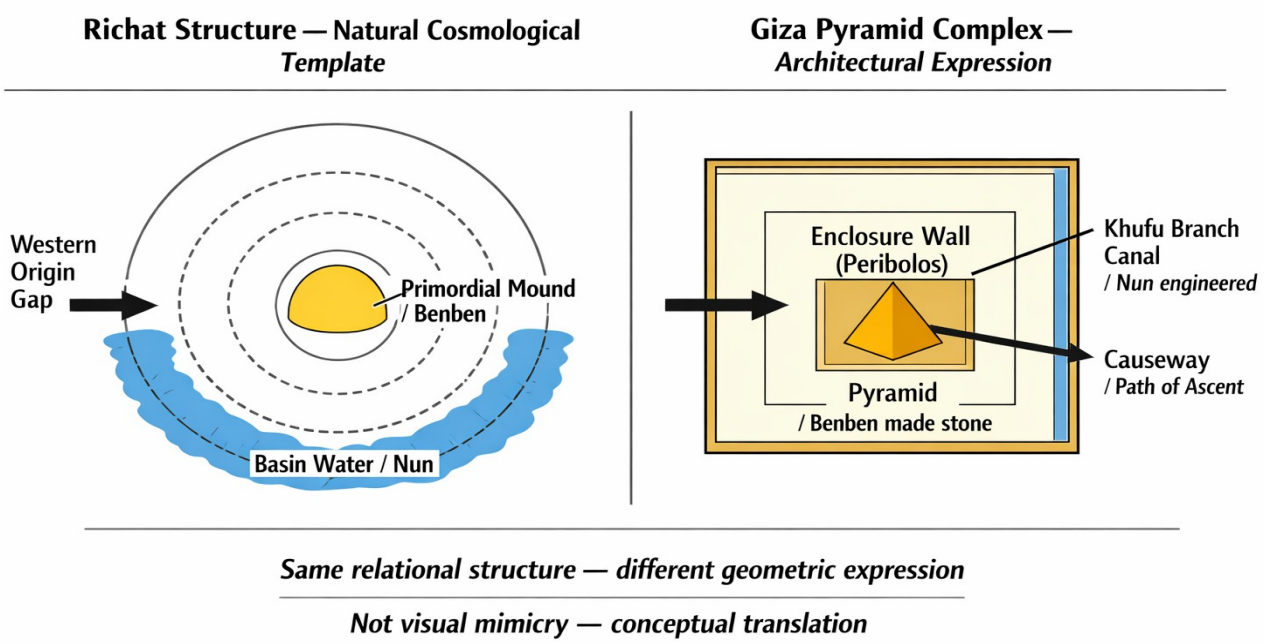
The western orientation of the Giza causeways is not merely a qualitative impression. A Total Station survey of the Giza complex by Nell and Ruggles (2014) measured Khafre's causeway at azimuth 103° 26′ from eight surveyed points, and Menkaure's at 89° 10′ from six — that is, 283.4° and 269.2° respectively when expressed in the westward sense, toward the pyramid. Khufu's causeway is largely destroyed and was not surveyed by them; earlier measurements give a deviation from cardinality of −14° to −15°, an azimuth near 255° (Lauer 1947; Goyon 1969; Lehner 1985). The three do not cluster tightly. What they do is deviate in opposed senses about the east–west axis: Khufu roughly 14.5° south of west, Khafre roughly 13.4° north of west, and Menkaure within a degree of cardinal. Nell and Ruggles themselves describe the approximate symmetry of the Khufu and Khafre causeways about due east–west as noteworthy, while cautioning that it need not have been an end in itself for the builders. The mean of the three azimuths is 269.4°, within 0.6° of due west. On the reading advanced here, the axis rather than any single causeway carries the orientation: three reigns produced three different deviations that resolve, taken together, to the cardinal westward line. This is a weaker pattern than uniform clustering would be, and it is stated as such.

The broader survey confirms that east-west orientation in relation to sunrise and sunset was "a, or even the, key factor" (Nell & Ruggles 2014) in the layout of many associated structures. Khufu's mortuary temple reflects the orientation of the Great Pyramid itself, with a deviation from cardinality of about one arc minute; Khafre's valley temple and the adjacent Sphinx temple are aligned very close to the meridian, and Menkaure's valley temple gives an east–west alignment of 90.2°/270.2°. Khufu's own valley temple is destroyed and could not be surveyed. The causeways thus participate in a directional grammar in which the western horizon—associated in Egyptian cosmology with the setting sun, the entrance to the netherworld, and the land of the dead—appears privileged. Khafre's northward deviation (283.4°) has an established alternative explanation: Nell and Ruggles, following Lehner (1997), suggest it arose from aligning the axis of the Sphinx temple, the south side of the Sphinx, and the south side of Khafre's pyramid. Magli (2010) additionally reads the Giza causeways within a solar framework. Neither explanation is excluded by the reading offered here, and both should be weighed against it. The two orientations — western origin and eastern theological culmination — operate within a single architectural complex, unified rather than contradictory. The organisation of all three causeways about the east–west axis, however, remains a feature of the Giza complex that invites explanation beyond purely utilitarian models.

The Giza Diagonal and Heliopolis

The directional grammar of Giza extends beyond the causeways to the placement of the pyramids themselves. Lehner (1985b: 143, n. 24) reports, from a 1983 newspaper account, Goedicke's proposal that the line of the Giza pyramids points toward Heliopolis and the ben-ben. Lehner's own discussion (1985b: 151) describes an organic development that accommodated thematic considerations alongside geological and topographical constraints; he does not assert a fully predetermined programme. The alignment is approximate rather than survey-grade precise, and visibility from Giza to Heliopolis remains debated. The Giza Diagonal is therefore treated here as a documented layout whose significance is disputed. Magli (2010, 2013) has argued for a deliberate symbolic orientation toward the Benben cult center; that is a proposal, not an established result.

Heliopolis was the cult center of the Benben — the primordial mound of Egyptian creation theology. If the Giza Diagonal was intended to point toward Heliopolis, it would relate the architectural mound, the pyramid, to the theological mound, the Benben at Heliopolis. That reading is a proposal of this series; Lehner (1985b: 151) describes the layout as an organic development under geological and topographical constraints rather than a fully predetermined programme. Within the framework of this series, Heliopolis is the formalised theological expression of the same cosmological grammar whose origin landscape is argued in Corridor I to be the Richat Structure. On this reading Giza points not toward the origin but toward where the origin was remembered.


Richat Structure — Natural Cosmological Template
Giza Pyramid Complex — Architectural Expression
Western Origin Gap
Primordial Mound / Benben
Basin Water / Nun
Enclosure Wall (Peribolos)
Khufu Branch Canal / Nun engineered
Causeway / Path of Ascent
Pyramid / Benben made stone
Same relational structure — different geometric expression
Not visual mimicry — conceptual translation

On the visual relationship between Richat and Giza: The correspondence proposed here is not visual or geometric. The Richat Structure and the Giza complex differ in scale, symmetry, and spatial organization. Richat is a large circular geological formation with concentric rings; Giza consists of angular, rectilinear architectural complexes. Richat's water system was basin-like and surrounding; the Nile branches at Giza were linear and localized. The argument advanced here is therefore not one of visual imitation. Rather, it concerns the instantiation of a cosmological grammar: a central elevated form, spatial separation between a sacred core and the surrounding world, water associated with the transition zone, and a directional orientation toward the west.

The western causeway at Giza exemplifies this directional grammar. The three causeway orientations documented by Nell and Ruggles (2014) and by earlier surveys deviate in opposed senses about the east–west axis and average to within a degree of due west, a configuration consistent with a

cosmological rather than a purely topographic determinant, though not by itself decisive between them. These elements are argued to have been re-expressed within the constraints and conventions of Old Kingdom Egyptian architecture. Such transformations from natural or symbolic forms into rectilinear architectural expression are consistent with broader patterns in Egyptian sacred design (e.g., the circular heb-sed court becoming the square temple plan). The homology proposed is structural and conceptual, not visual.

The Pyramid Texts place the dead king's destination in the west. Utterance 257 (antechamber west wall of the Unas pyramid, c. 2375–2345 BCE) has the king set in the west with those of the Duat following him (Allen 2015). Utterance 214 (burial chamber, south side) says the king shall be *at the fore of the westerners* (Allen 2015). Leadership of the westerners is among the highest epithets of the transformed king in Egyptian theology. The reading proposed here is that the western bearing of the Giza causeways is consistent with that theology; the texts themselves do not describe the Giza causeways.

The Bull's Foreleg: Giza's Stellar Anchor

The most precise architectural feature of the Great Pyramid — its alignment to true north within about 4 arc minutes — was achieved, on the most extensively developed peer-reviewed model, by observation of the constellation Meskhetyu (the Bull's Foreleg, equivalent to the modern Plough or Ursa Major). Belmonte (2001) demonstrates that the simultaneous meridian transit of Megrez and Phecda — two stars of the Bull's Foreleg — provided the reference for accurate north-south orientation, with the alignment achieving its greatest precision at approximately 2562 BCE. Belmonte's Figure 3 shows Meskhetyu at lower culmination in 2562 BC, with the line through Phecda and Megrez marking the position of the pole and of due north (Belmonte 2001: S12, Fig. 3). He reports that the dates this gives for Khufu's accession fall in the middle of the range of chronologies accepted today by Egyptologists (Belmonte 2001: S12). The same procedure has been proposed at the predynastic structure HK29A at Hierakonpolis (Kom el-Ahmar) and at the Osireion of Seti I at Abydos (Belmonte and Shaltout 2010: 537–538, Fig. 8; Belmonte 2001) — spanning more than two millennia of Egyptian sacred architecture.

The alignment procedure itself belonged to a ritual tradition of far greater antiquity: the "stretching of the cord" ceremony, whose surviving Ptolemaic temple texts name Meskhetyu as the celestial target toward which the king looked when fixing a temple's orientation. In Lull's reading the Edfu text leaves no doubt that the asterism of Meskhetyu served to orient the temple (Lull 2008: 91), and the foundation inscription of the temple of Hathor at Dendera, of 54 BC, has the king found the temple with his gaze toward the Akh of Meskhetyu (Lull 2008: 92). The ceremony depicted on these temple walls preserves a ritual grammar whose architectural expression at Giza predates its surviving textual form by more than two millennia.

Meskhetyu was, in Belmonte's phrasing, "one of the most important asterisms of Egyptian religion since at least the Old Kingdom, if not earlier" (Belmonte and Shaltout 2010: 537). It appears in the Pyramid Texts as the "imperishable star" per excellence — the destination of the king's ascent. Meskhetyu corresponds to the Big Dipper within Ursa Major (Lull 2008: 85). The constellation's dual identity — adze and bull's foreleg — is documented in the Egyptian textual record itself: the name is written with an adze determinative already in the Pyramid Texts (Spell 302, Pyr. 458b–c), and the adze could also appear with the determinative of a bull's foreleg (Nemes 2020: 1–2). Nemes does not date the foreleg spelling. Coffins of the Ninth to Eleventh Dynasties show Meskhetyu as a bull's foreleg formed of seven stars arranged like the Big Dipper, and the oldest mentions in the Pyramid Texts, from the reign of Unas, are about three centuries older than the oldest depictions (Lull 2008: 86, Fig. 1). The same constellation is used in the Opening of the Mouth ritual, where the bull's foreleg is the implement by which the senses of the deceased are restored. The province of Letopolis, whose capital sat near Heliopolis, bore the name "Bull's Foreleg" (Belmonte 2010).

This is structurally significant. The herd for the dead defined in Corridor II (Levy 2026b) and the predynastic cattle cult at Hierakonpolis HK6 documented in Shemsu Hor (Corridor III, Levy 2026c) — including the deliberate horn modification of livestock first attested anywhere in the world (Van Neer et al. 2024) — share a single unifying symbol with the constellation that anchored the Great Pyramid's most precise architectural alignment. The pairing of adze and bull's foreleg in the name's writing traces the same symbolic chain — implement, animal, constellation — that connects the pastoralist bull cult at HK6 to the astronomical orientation at Giza. The bull on the ground at Hierakonpolis and the bull in the sky over Giza are not separate phenomena. They are the same symbol expressed at different scales: ritual, anatomical, celestial, and architectural. The Bull's Foreleg connects the cattle pastoralism of the Saharan corridor to the stone of the Old Kingdom by the most direct route imaginable — the orientation procedure used to set the cardinal axis of the monument itself.

Phase Zero: The Pyramid Tradition Predates Khufu

A standard objection to any cosmological reading of Giza is that the pyramid form itself emerged in the 4th Dynasty as a royal innovation. The archaeological record contradicts this. Seven small step pyramids — collectively known as the Minor Step Pyramids (MSPs) — were built in the late 3rd and early 4th Dynasty at provincial centers across Upper and Middle Egypt, built in the generation before Khufu, most probably under Sneferu (Ćwiek 1998). Dreyer and Kaiser (1980) first identified them as a coherent group; Ćwiek (1998) systematized their dating and function; Belmonte, Shaltout and Fekri (2005) measured their orientations and proposed astronomical interpretations that, in their words, in no way abandon the Nile hypothesis; and Marouard and Papazian (2012) have re-investigated the Edfu MSP in the field, confirming the late 3rd / early 4th Dynasty horizon. The MSPs are located at or near the most important provincial capitals of the Old Kingdom: Abu (Elephantine), Behedet (Edfu), Nekhen (el-Kula at Hierakonpolis), Nubt (Naqada), and This-Abydos (Sinki).

The fullest pre-Khufu expression of this tradition at royal scale is Djoser's Step Pyramid at Saqqara (c. 2,650 BCE), designed by Imhotep. The Step Pyramid is the first full-scale stone pyramid in the Egyptian record and the first monument to integrate the pyramid form with a comprehensive royal cosmological program: stellar north orientation, enclosure walls mimicking the palace facade (per-ineb), and a Heb-Sed court designed specifically to provide a location for the king's ka to perform regenerative rituals after death. Djoser's complex is architecturally pivotal because it demonstrates that the institutional infrastructure — a dedicated priestly class, a stellar-oriented pyramid, a ka-ritual tradition — was fully operational at royal scale some decades before the 4th Dynasty. The MSPs and Djoser's Saqqara complex together establish that Khufu's architects inherited a tradition already mature in both its cosmological grammar and its monumental expression.

The el-Kula pyramid is the case that closes the loop. Located approximately six kilometers from the predynastic cattle cult center at Hierakonpolis HK6, el-Kula is oriented at a quarter-cardinal axis ~44° west of north, with a secondary axis declination of 66¾° placing the orientation on Meskhetyu at lower culmination in the Old Kingdom epoch (Belmonte, Shaltout & Fekri 2005, Table 1). Its sister structure at El Ghoneimiya is annotated in the same table as the "lowest latitude in Egypt where Meskhetyu is circumpolar" (Belmonte, Shaltout & Fekri 2005: 11). Belmonte, Shaltout and Fekri place El Ghoneimiya, El Kula, Sinki and Seila in a group with cardinal or quarter-cardinal orientations, interpreted through a north–south reference used directly or rotated by 45° (Belmonte, Shaltout and Fekri 2005: 13). Belmonte and Shaltout connect the quarter-cardinal tradition with Meskhetyu and illustrate a possible simultaneous Megrez–Phecda transit at Hierakonpolis HK29A, at Seila and at the Osireion (Belmonte and Shaltout 2010: 537–538, Fig. 8). Phase Zero (Levy 2026d) develops this point at length: el-Kula is the architectural-astronomical expression of the same Bull constellation whose physical analogue — the cattle herd — defined the material culture at the same site.

The implication for the present paper is direct. The cosmological grammar of the Giza complex did not appear ex nihilo in the 4th Dynasty. By the time Khufu's architects laid out Akhet-Khufu, the pyramid form, the stellar orientation procedure, and the bull-symbol cosmology had already been operating in

stone at provincial centers across Upper Egypt. The 4th Dynasty did not invent the pyramid tradition. It monumentalized it. The MSPs are the missing intermediate stage between the predynastic cattle cult at HK6 (c. 3700 BCE) and the Giza complex (c. 2580–2540 BCE) — an architectural bridge that materially confirms the institutional continuity required by the Shemsu Hor transmission model (Corridor III).

The Zep Tepi cosmology describes the primordial mound emerging from the waters of Nun — a landscape of water and elevation, of boundaries and directional axes. The preceding sections have established that the Giza pyramids encode this relational system in their external form. But that encoding depends on a physical premise: the water must actually have been there. This section reviews the hydrological evidence confirming that it was.

The Khufu Branch Canal (2022 PNAS Study)

For centuries, a fundamental logistics problem remained unsolved: the Nile today runs several kilometres from the Giza plateau. How did multi-tonne stone blocks get from the river to the construction site? In 2022, Hader Sheisha and colleagues published findings in *PNAS* confirming the existence of the 'Khufu Branch' — a now-buried Nile channel that ran directly to the base of the Giza plateau during the Old Kingdom. Using pollen-derived vegetation patterns from sediment cores, they reconstructed 8,000 years of fluvial variation on the Giza floodplain and found that the Khufu branch remained at roughly 40% of its Holocene maximum water level through the reigns of Khufu, Khafre and Menkaure — a level they conclude facilitated the transportation of construction materials to the site. Merer's diary confirms the practical use, as the inspector describes the 'Lake of Khufu' as a delivery point for limestone blocks (Tallet 2017; Tallet & Lehner 2021).

The Ahramat Branch (2024 Study) and the Khufu Harbour

In 2024, Eman Ghoneim and colleagues published findings in *Communications Earth & Environment* identifying a larger extinct Nile branch — the Ahramat ('Pyramids') Branch — running alongside 31 Egyptian pyramids, using radar satellite imagery, geophysical survey and sediment cores. Many of the causeways associated with those pyramids run perpendicular to the reconstructed branch and terminate at valley temples, which Ghoneim and colleagues interpret as river harbours.

The harbour detail matters. A 2024 study led by Younes, Marriner, Kaniewski, and Sheisha extracted sediment core Giza-3 from the proposed harbour basin itself. Their reconstruction places the Khufu harbour at the core site, confirms Lehner's earlier model of it, and dates the sampled harbour deposits to the pyramid-building period; it puts the harbour floor about 3 m higher than Lehner's model and records the harbour's later abandonment (Younes et al. 2024: 1, 9–10). The basin is described there as built in Khufu's reign (p. 1); the core itself does not separately demonstrate deliberate cutting or maintenance, or use across later reigns.

The Cosmological Significance of the Water

The canal and the river branch were integral to the design. The pyramid was meant to rise from water. The Zep Tepi describes the primordial mound emerging from the waters of Nun. The architects engineered the water to be there. When viewed from the Nile, the pyramid would have appeared to rise directly from the water — exactly as the Benben rises from Nun.

A note on functional versus symbolic interpretation: The proposed framework does not deny that the Khufu Branch canal served logistical purposes (stone transport) or that the causeway facilitated construction. Rather, it argues that functional systems were organized in accordance with a pre-existing cosmological structure. Dual-use is not a weakness of the hypothesis but an expectation: sacred architecture routinely co-opts practical infrastructure. The Egyptians did not have to choose between building a canal for transport and building a canal that symbolically enacted Nun. They did both simultaneously.

The valley temples are positioned at the water's edge, with causeways running up to the mortuary temples. The causeway is the cosmological axis of ascent — the path from water to mound, from Nun to Benben, from mortal to divine. Every procession along the causeway enacted the Zep Tepi.

This cosmological logic was not confined to the plateau's surface. The Osiris Shaft — a multi-tiered subterranean structure descending 30 metres into the Giza bedrock, located beneath the causeway connecting the Sphinx to the Second Pyramid (for the Sphinx's own dating and proposed original name, see Levy 2026e) — provides independent confirmation that water's cosmological role at Giza was enacted at every level of the landscape. At its lowest tier, the builders descended to the actual Nile water table and constructed a central island surrounded by a groundwater-fed moat. Hawass (2007: 388, 391–392) describes the water-surrounded emplacement and compares it with the Osireion at Abydos; he interprets the water in relation to Osiris, resurrection and the primeval mound surrounded by Nun (Hawass, Z.A. 2007. "The Discovery of the Osiris Shaft at Giza."

In Hawass and Richards (eds.), The Archaeology and Art of Ancient Egypt: Essays in Honor of David B. O'Connor, Vol. I. ASAE Cahier 36. Cairo: Supreme Council of Antiquities, pp. 379–397). The Giza plateau was known in the New Kingdom as pr wsir nb rstaw — "the House of Osiris, Lord of Rostau" — Rostau meaning cemetery or underground tunnels and usually referring specifically to Giza, and the water-filled trench around the central emplacement of the lowest chamber forms the shape of the pr ("house") hieroglyph (Hawass 2007: 391–392; for the Shetayet of Sokar at Rosetau, Edwards 1986). The plateau's New Kingdom name is read here as consistent with an underground cosmological function: the entire Giza complex, from its engineered harbour at the surface to the water table 30 metres below, was understood as a single cosmological landscape. The Osireion of Seti I at Abydos replicates the same island-in-water design, identified by Egyptologists as a physical enactment of Nun with the Primordial Mound at its centre (Frankfort, de Buck & Gunn 1933). That two major sacred sites — Giza and Abydos — built to the same subterranean Nun cosmology template establishes an architectural typology: the island-in-water Nun chamber was a documented method of physically instantiating the creation moment at Egyptian sacred sites. The causeway carried the cosmological grammar above ground; the Osiris Shaft carried it below.

The Osiris Shaft and the Pyramid: A Designed Cosmological Pair

The tradition of paired cosmological structures at a single royal site is documented in Egyptian architecture before Khufu. Magli (2016, Time and Mind 9(1): 57–74) argues that duality in the funerary cult is a defining characteristic of the pyramid tradition from its origins: Djoser's Step Pyramid complex at Saqqara contains two almost identical underground tombs — one beneath the pyramid and one at the south boundary — and Snefru's Dahshur project pairs two pyramids with complementary cosmological functions. Magli's central argument in that same Time and Mind paper is that the Giza plateau itself was conceived as a unified "written landscape" in which the Khufu and Khafre complexes form a single double project — a cosmological statement neither complex can make alone. The Osiris Shaft sits beneath the Khafre causeway, inside this documented landscape. Academic Egyptology further recognises that the Duat was conceptualised simultaneously as subterranean and celestial — not one or the other (Hornung 1999, The Ancient Egyptian Books of the Afterlife, Cornell University Press; Zago, S. 2022. A Journey through the Beyond. Lockwood Press — documenting that within the Pyramid Texts "the Duat's location and features [were] conceived as flexible and variable").

The pyramid's ascending chambers enact the celestial Duat; the Osiris Shaft enacts the subterranean Duat. Both are the Duat. The shaft enacts the same three cosmological registers as the pyramid — the living world, the realm of the dead, the primordial waters — but stacked top-to-bottom as descent, inverted against the pyramid's bottom-to-top ascent. On the hypothesis that Giza encodes the Zep Tepi cosmological system at landscape scale, the pyramid and the shaft may together constitute its complete expression: descent to the primordial waters of Nun and ascent to the Imperishable Stars, the full arc of the cosmological circuit encoded permanently across 270 metres of plateau.

The Edfu Building Texts as Corroboration

The Edfu Building Texts describe a primeval island, its principal name the Island of Trampling, set in the primaeval waters, on which the first sacred domain is founded and the Great Primaeval Mound comes into being (Reymond 1960: 14–17). Reymond judges that in all probability every temple in Egypt could claim to be the original temple and site of creation (Reymond 1960: 180). The Edfu records themselves do not locate this homeland; Reymond found no definite evidence of where the First Province of the Falcon lay (Reymond 1960: 180). She argued instead that the Edfu tradition had a pronounced Memphite background (Reymond 1960: 181). The oldest religious texts face west. In the pyramid of Unas, Thoth is sent to “announce to the gods of the West as well as their akhs” the king’s arrival, “arrayed on the neck as Anubis at the head of the western height” (PT 217; Allen 2015: 36), and the king is to stand “at the fore of the akhs as Anubis at the fore of the westerners” (PT 81; Allen 2015: 25). Pepi I is told: “you should not go away in those eastern lands, but you should go away into those western lands, in the path of the Sun’s followers” (PT 578; Allen 2015: 187). The archaeological record supplies the movement those texts face: the exodus from the Egyptian Sahara “coincides with the rise of sedentary life along the Nile”, where “Saharan traditions of cattle pastoralism have thus become an essential component of Neolithic life in the Nile valley” (Kuper & Kröpelin 2006: 806).

The institutional context for this transmission is materially documented at Edfu itself. The temple's "house of the book" (pr mDAt) preserved a catalogue of the titles of the books in its library, which includes works on astral knowledge (Winkler 2021, section 4, citing Neugebauer). The presence of a library with astronomical titles at the very temple whose Building Texts invoke the architectural knowledge of the Shemsu Hor is consistent with the model of institutional transmission proposed here: an active scribal tradition preserving and applying celestial observations across millennia, from the time of the Followers of Horus to the Ptolemaic period.

The medieval Islamic tradition regarding the pyramids represents a sophisticated intellectual effort to integrate pre-Islamic monuments into a sacred, universal history. Modern scholarship has recognized that Islamic scholars "recreated the pyramids as evidence of a vanished antediluvian world of scientific wonders whose glories anticipated those of Islam" (Colavito 2021); El-Daly (2005) sets out the broader case that medieval Arabic writers engaged seriously and systematically with Egyptian antiquity.

The Surid Legend: Antediluvian Knowledge in Stone

The most detailed Arabic tradition attributes the pyramids to Surid ibn Salhouk (also known as Saurid), a legendary king said to have ruled Egypt 300 years before the biblical Great Flood. According to al-Mas'udi's 10th-century *Akhbar al-Zaman*, Surid dreamed of a cataclysm — "the fixed stars had come down" and "had grabbed the people and had hurled them between two mountains" — which he interpreted as divine warning of an impending deluge. In response, he commanded the construction of the pyramids as repositories for "the sciences of arithmetic, geometry, astronomy, and medicine," along with the mummified bodies of his royal ancestors and their treasures.

Scholarly analysis traces this legend to Coptic Christian adaptations of older Gnostic or Sabian lore around the 4th–5th centuries CE, with Surid representing a conflation of the historical pharaoh Khufu (Suphis in Manetho) with prophetic archetypes such as the biblical Enoch, the Islamic Idris, and the Greco-Egyptian Hermes Trismegistus (Fodor 1970). The name "Surid" itself derives from "Suphis" — the Greek rendering of Khufu's name. As one analysis notes, "The story of Surid and his antediluvian construction of the pyramids assigns to them a place in sacred history and establishes a neutral narrative ground upon which Muslims and Christians could agree" (Smith 2007: 14).

The legend is not treated here as literal history. But the methodological literature on traditional transmission cautions equally against the opposite error of dismissing such material as pure invention. Vansina (1985) established that traditions may preserve recoverable information across long transmission chains when assessed critically, and Barber and Barber (2004) document cases in which

myth demonstrably encodes real events — the Klamath account of the formation of Crater Lake, for instance, corresponds to the geological record of the eruption and was transmitted for roughly eight thousand years. The relevant question for the Surid tradition is therefore not whether it is history, but whether its specific and unusual claim — that the pyramids were built as repositories of arithmetic, geometry, and astronomy — preserves a kernel of the encoding logic proposed here, however distorted by its later Coptic and Hermetic transmission.

Al-Ma'mun and the Opening of the Great Pyramid

The Abbasid Caliph al-Ma'mun (r. 813–833 CE) is credited with the first documented entry into the Great Pyramid during the Islamic period. According to Arabic sources, he was "seized with the desire to open them" and employed fire, acid, iron tools, and catapults to breach the structure (Al-Maqrizi, *Al-Khitat*). While the caliph's brief stay in Egypt makes his personal involvement unlikely, scholars note that "it may be presumed that it was about that time that further progress into the interior of the Pyramid of Cheops was made for the first time in the Muslim period," motivated by the widespread belief that "rich treasures were concealed there" (*Encyclopaedia of Islam*, Brill).

The Flood Narrative: Knowledge Preserved Before Catastrophe

The Islamic tradition's emphasis on the pyramids as antediluvian repositories of knowledge has thematic resonance with the Zep Tepi framework. This resonance is noted as corroborative folklore, not as historical evidence. The Surid legend is a post-pharaonic Arabic construction with no documented continuity from Old Kingdom sources; it cannot serve as independent confirmation of any claim made in this paper and is presented here solely to establish the depth and persistence of the knowledge-preservation reading of the pyramids across cultural traditions. A 17th-century English account of Arabic traditions reports that the greatest part of the chroniclers attributed the building of the pyramids to Surid ibn Salhouk, king of Egypt, who lived 300 years before the Flood (Greaves 1646).

Parallel to the Zep Tepi Hypothesis: This tradition — of knowledge encoded in stone before a catastrophic deluge — mirrors the Green Sahara's termination by the African Humid Period's "flickering" dry events (Trauth et al. 2024), which this series has argued created the migration pressure that carried the Zep Tepi cosmology to the Nile Valley. The Islamic scholars who walked into the empty chambers and sensed that knowledge was present were not wrong. They simply could not identify the form in which it was encoded. The knowledge was not inside the pyramid in scrolls or tablets. It was the pyramid's form itself.

Early Attempts at Hieroglyphic Decipherment

Significantly, Arabic scholars made early attempts to decipher hieroglyphs. In the 10th century, the Iraqi scholar Ibn Wahshiyya published *Kitab Shawq al-Mustaham* (*Ancient Alphabets and Hieroglyphic Characters Explained*), in which he recognized that Egyptian symbols represented words — an insight that anticipated Champollion by 800 years. The 1806 English translation notes that Ibn Wahshiyya "claimed to have been able to decipher many ancient Egyptian hieroglyphic signs, identifying their phonetic values and meanings". While some scholars are skeptical of his success, others credit him with anticipating Champollion and Young by recognizing that hieroglyphic signs had phonetic as well as symbolic values. This intellectual heritage places Islamic scholarship at the origins of Egyptology.

Modern non-destructive scanning technologies have opened a new chapter. The ScanPyramids project (Cairo University and France's HIP Institute, launched 2015) has used muon tomography, ground-penetrating radar, and electrical resistivity to detect previously unknown interior spaces.

The Big Void (2017)

In November 2017, the ScanPyramids team published in *Nature* the discovery of a large unknown void above the Grand Gallery (Morishima et al. 2017). Confirmed by three independent detection methods,

the void is at least 30 metres long. Its purpose remains unestablished. Two peer-reviewed construction-infrastructure interpretations have since been proposed. Rosell Roig (2026), using a coupled parametric-geometry / discrete-event-logistics / finite-element framework, suggests that several muography anomalies (including the Big Void and the North Face Corridor) may be partially related to backfilled construction infrastructure: temporary edge-integrated ramps later closed top-down. Scheuring (2025) independently argues that the Grand Gallery and Ascending Passage functioned as sliding-ramps for a counter-weight pulley system, with the Big Void and North Face Corridor representing upper sliding-ramp infrastructure. Both authors are explicit that these are hypothesis-generating correspondences rather than confirmed void geometries, and that current scanning resolution cannot distinguish construction infrastructure from other heterogeneities. These interpretations are mentioned here for completeness; they are not in tension with the cosmological reading developed in this paper, since construction technique and architectural symbolism operate on independent dimensions.

The North Face Corridor (2023)

In March 2023, the ScanPyramids team published in *Nature Communications* the confirmation of a hidden corridor on the pyramid's north face (Procureur et al. 2023). The corridor is approximately 9 metres long, located behind the chevron blocks above the main entrance. The endoscope captured bare limestone walls and a vaulted ceiling — no artifacts. The corridor was subsequently confirmed by two independent multimodal studies: Schumacher et al. (2025) combined ground-penetrating radar, ultrasonic testing, and electrical resistivity tomography in a discrete-wavelet-transform image fusion, and Pugacheva et al. (2025) applied ERT alone to provide volumetric data, reporting average internal dimensions of approximately 2.5 m by 2.5 m, beginning at a depth of about 1 m and extending at least 2 m into the pyramid. The corridor's existence is therefore established by four independent geophysical methods (muon tomography, GPR, UST, ERT) across three peer-reviewed publications. Rosell Roig (2026) reports that the four-ramp configuration of the IER predicts an upper haulage lane crossing the north face at approximately 39.4 m elevation with a horizontal setback of about 13.4 m — a position the author identifies as a quantitative geometric coincidence with the NFC depth envelope reconstructed from Pugacheva et al. (2025). The author explicitly characterizes this as geometric correspondence rather than functional attribution, and the present paper retains the cosmological reading of the chevron blocks (their visual resemblance to the akhet hieroglyph) as a separate, complementary line of analysis.

> *The V-shaped chevron blocks above the main entrance bear a visual resemblance to the akhet hieroglyph — the horizon. The pyramid's own name, Akhet-Khufu, means 'Horizon of Khufu.'*

Menkaure Voids (2025) and the Hawass Sealed Corridor (2025)

In late 2025, researchers published findings in *NDT & E International* identifying two previously unknown air-filled voids behind the eastern granite facade of the Menkaure pyramid (Helal et al. 2025). The first void is located at a depth of approximately 1.4 m, with dimensions of roughly 1.0 m by 1.5 m; the second is at a depth of approximately 1.13 m and measures approximately 0.9 m by 0.7 m. Both lie behind a section of unusually polished granite blocks (about 4 m by 6 m) on the eastern face whose finish resembles the polished surround of the known northern entrance. Helal and colleagues interpret the voids as supporting the hypothesis — previously raised on architectural grounds — that the eastern face once concealed a second, unopened entrance.

In November 2025, Egyptologist Zahi Hawass announced at a public book fair the discovery of a 30-metre corridor inside the Great Pyramid ending at a sealed door (Egypt Independent, 9 November 2025). **At the time of writing, this finding remains a news announcement only; no peer-reviewed publication has appeared. Pending peer-reviewed publication, this paper does not rely on this unverified discovery as evidence.** The present analysis therefore restricts itself to the peer-reviewed discoveries (Big Void, North Face Corridor, Menkaure voids).

Together, the peer-reviewed discoveries (Big Void, North Face Corridor, Menkaure voids) confirm that the Giza pyramids are not fully mapped. These structures, built 4,500 years ago, are still revealing their geometry. Ongoing systematic scanning has now extended to the Pyramid of Khafre: the ScIDEP (Scintillator Imaging Detector for the Egyptian Pyramids) Collaboration is constructing muon telescopes to scan Khafre from multiple viewpoints, both inside the king's burial chamber and from the exterior (Gamal et al. 2025). No interior scan data has been published from Khafre at the time of writing; but the instrumentation development and simulation framework are complete, and the project represents the systematic extension of pyramid scanning beyond Khufu.

The preceding sections have established the landscape-scale argument: that the Giza complex instantiates, at architectural scale, the four-element relational system that originated in the Richat landscape and was carried northeast through three thousand years of documented institutional memory. The following section examines the second register of the hypothesis. Where the landscape-scale argument is primarily spatial and relational, the dimensional-scale argument is mathematical and astronomical: it proposes that the pyramid's exterior measurements preserve, through the Wedjat binary fraction system, a structured body of knowledge whose scope extends from fundamental constants of geometry to multi-generational stellar cycles. The two registers are independent lines of evidence. Their convergence on the same structure is the core of the hypothesis.

The Encoded Memory: What the Pyramid May Preserve

This section presents a structured investigation into mathematical and astronomical correspondences between the Great Pyramid's surveyed exterior dimensions and a range of constants, cycles, and quantities spanning multiple domains of knowledge. Calculations use the reconstructed design values supported by Petrie's (1883) and Dash's (2012) surveys, with the exact Wedjat binary fractions. Results were independently verified by arithmetic computation (see AI Use Disclosure). The mathematical relationships documented here are arithmetically verifiable by any reader. The interpretation — that they represent deliberate, structured knowledge preservation by the tradition described in The Corridor Series — is this hypothesis's central claim. It is not proof. Readers are invited to evaluate whether the pattern of correspondences, their precision, their domain coherence, and their structural consistency are more consistent with deliberate encoding or with coincidental numerical proximity.

The section is tiered. Findings whose underlying geometric and metrological relationships are documented in peer-reviewed literature are identified as established, with citations. Mathematical correspondences proposed as novel observations specific to this hypothesis are explicitly noted as such. The distinction is maintained throughout. No claim is presented as more certain than the evidence supports.

The peer-reviewed foundation for the mathematical claims in this section is threefold. At the metrological level, Zapassky, Gadot, Finkelstein and Benenson (2012, PLoS ONE) propose, on the basis of measurements of large sets of ancient vessels, that Egyptian capacity measurement used a sphere-based relation: a sphere whose circumference is one royal cubit has a volume of 0.5066 hekat by their calculation, which they describe as about half a hekat (Zapassky et al. 2012: 2). They report that the relation is characteristic of Egyptian and Egyptian-related pottery and not of Mesopotamian ceramics. The authors note that royal cubit rods kept in Egyptian temples carried inscriptions affirming their spiritual significance — "The cubit is life, prosperity, and health, the repeller of the rebel" — consistent with this paper's argument that Egyptian metrology was cosmologically embedded. At the construction geometry level, Rossi (2003, Cambridge University Press; corrected reprint 2006) shows that the 280:220 proportions of Khufu's pyramid correspond to a seked of 5½ palms, that the numbers 14 and 11 are consequences of that seked, and (Appendix) catalogues over eighty Old and Middle Kingdom pyramids (Rossi 2003: 204, 215–216). That the canonical dimensions (base 440 cubits, height 280 cubits) yield approximations of π and φ follows arithmetically from those proportions; the attribution of the π and φ readings to Rossi has not been checked. This paper's additional claim is that

the seked of 5 ½ was selected from the Wedjat fraction system precisely because it produces these relationships, not merely as a practical construction convenience. That claim requires a direct answer to the standard objection, which is set out and addressed below. At the astronomical level, the Sothic cycle target value used in the calendar correspondences below (1,461 civil years) was documented in Egyptological scholarship by Poole (1851, Horae Aegypticae) — one hundred and seventy-five years before this paper — as a universally acknowledged fact of Egyptian astronomical knowledge. It is not a value invented by this hypothesis.

Relation to Prior Scholarship

Nothing in the arithmetic below is original to this paper, and the debts should be stated plainly. That the Egyptians employed a closed series of binary submultiples — ½, ¼, ⅛, 1⁄16, 1⁄32 and 1⁄64 — in the division of the hekat is established through the work of Gillings (1972) and Clagett (1999) on the Rhind Mathematical Papyrus and the associated corpus, and the internal arithmetic of that series has been analysed at length in studies of the Akhmim Wooden Tablet, the Egyptian Mathematical Leather Roll and the Rhind 2/n table. Pommerening (2003) demonstrated that the same series governs pharmaceutical measurement in the Ebers Papyrus, an attestation independent of grain administration. The identification of the series with the anatomical components of the wedjat eye originates with Möller (1911) and entered the standard reference literature through Gardiner (1927). The seked of 5½ palms for Khufu's pyramid is documented by Rossi (2003: 215–216); the π- and φ-proportions discussed above follow arithmetically from it, and their attribution to Herz-Fischler (2000) has not been checked against that source. The dimensions themselves derive from Petrie (1883) and the Lehner–Goodman survey as analysed by Dash (2012). This paper contributes none of these findings and depends on all of them.

The derivation of the series from the wedjat has since been challenged. Ritter (2002) argued that the hieratic capacity-measure submultiples, in their origin and their written form, did not visually derive from the pictographic components of the eye, and that the association was a later interpretive overlay rather than the source of the notation. That argument is, in the present author's view, well founded, and it is accepted here. Its scope should be stated precisely, since three separable questions are easily conflated. The first is whether the hieratic fraction signs derive visually from eye-parts; this is Ritter's subject, and his conclusion is accepted. The second is whether the individual senses were associated with the Eye of Horus formula in Old Kingdom ritual; this is independently attested in the Unas offering liturgy (Pyramid Texts, Utterances 22–171) and is not addressed by Ritter. The third is whether the six senses correspond to the six fraction values in a specific ordered sequence; that correspondence is an inference rather than a directly attested Old Kingdom statement, and it is treated throughout this series at a lower evidential tier than the attestations that support it. Ritter's finding bears on the first question only. It does not reach the second or third, and it does not touch the existence, composition or use of the binary series itself.

The series is attested independently of the symbol in grain administration (Gillings 1972; Clagett 1999) and in pharmacy (Pommerening 2003), two domains that would not share a notation by convention alone. Its earliest attestation is in the Fourth Dynasty accounting papyri from Gebelein, the oldest known, which already use the full range of signs from ½ to 1⁄64, a completeness not matched again until the Middle Kingdom (Ritter 2002: 306, citing Posener-Kriéger 1994). The series was therefore in administrative use within the dynasty that built the Great Pyramid; whether it appears in the accounts of Khufu's own reign is testable against the grain accounts among the Wadi al-Jarf papyri (Tallet 2017). The Wedjat image itself is not attested before the Third Dynasty (Sherkova 2023), and the amulet not before the later Old Kingdom (Andrews 1994). What bears on the present analysis is a separate matter, and it does not come from Ritter: the six-sign series ends at 1⁄64 hekat, and finer quantities were expressed by combining the series with the ro, of which a hekat contained 320 (Peet 1923: 25). That endpoint of the notation is the boundary the analysis below relies upon. The present paper employs the series and its combinations only. No step in the arithmetic that follows depends on the sense correspondence or on the derivation of the sign, and the results would stand unchanged if

both were set aside. The term ‘Wedjat fractions’ is retained as the conventional designation for the series, in the sense in which the literature uses it, and not as an assertion about its origin.

What this paper proposes as new is neither the fractions nor the constants but the method. The series is here treated as a constrained computational grammar and tested as such: a fixed set of six exterior dimensions, the six fractions and their sums, the two operations attested in the Rhind Papyrus, a stated tolerance, and a target list frozen for the reported reanalysis after the initial correspondences were identified — with the resulting correspondence count compared against rival historical fraction systems downsampled to equal cardinality, against randomly generated systems of matched size and span, against evenly spaced systems of matched spacing, against the complete grids of neighbouring denominators, and against randomly generated pyramid proportions. A search of the published literature has not identified a prior application of the Egyptian binary series to monument dimensions under declared operational constraints with statistical controls of this kind. Existing work on the series concerns its internal arithmetic, its attestation, or its iconographic history; existing work on pyramid metrology proceeds in modern units and without a fraction-system null. The combination is, to the present author’s knowledge, untried, and is offered on that basis rather than as a claim of priority over any particular finding.

The Seked Objection

The strongest standing objection to any claim that the Great Pyramid encodes π or φ is that both follow automatically from its slope, and that the slope was chosen for practical reasons. The objection deserves to be stated at full strength. Egyptian builders expressed inclination as a seked — a number of horizontal palms and digits per royal cubit of rise — and the royal cubit divides into seven palms of four digits, twenty-eight digits in all. A seked of 5 ½ palms is therefore 22 digits horizontal to 28 vertical. The reciprocal, 28/22, equals 1.272727. It happens that 4/π equals 1.273240, a difference of 0.040%, and that √φ equals 1.272020, a difference of 0.056%. Both are well-documented coincidences arising from the number seven. On this reading, a builder who selects a whole-and-half-palm seked for ease of construction obtains π-proportions and φ-proportions in the finished monument without possessing, or intending, either constant.

Two things follow from this, and they should be separated. The first is granted without reservation: because the ratio alone determines both relationships, π and φ are not two independent correspondences but a single fact expressed twice, and every pyramid built to a seked of 5 ½ possesses both regardless of its size. They are accordingly listed in this section as established findings, arithmetic consequences of the seked documented by Rossi (2003: 215–216); Herz-Fischler (2000), attribution unchecked, rather than as novel claims. The second does not follow. The objection assumes that a seked of 5 ½ was adopted for convenience, and offers no evidence that it was. Convenience does not select it. A builder working in whole and quarter palms had at least eight equally practical values available across the range used for large pyramids, and their perimeter-to-height ratios are 5.714 at seked 5, 6.000 at 5 ¼, 6.286 at 5 ½, 6.571 at 5 ¾, 6.857 at 6, 7.143 at 6 ¼, 7.429 at 6 ½ and 8.000 at 7. Against 2π = 6.28319, the errors are 9.05%, 4.51%, 0.040%, 4.59%, 9.14%, 13.7%, 18.2% and 27.3% respectively. One value out of eight lands on 2π, and it lands two orders of magnitude closer than its nearest neighbour. Khafre’s pyramid, built on the same plateau within the same dynasty by the same institutional apparatus, uses a seked of 5 ¼ and misses 2π by 4.5%. Practical convenience alone does not uniquely select 5½ from these alternatives; whether its close 22/7 relation influenced the choice remains open. The objection explains π and φ given the seked; it does not explain the seked. That question remains open, and this paper’s proposal — that 5 ½ was selected from within the Wedjat system because of what it produces — remains a live candidate answer rather than one the objection has displaced.

A related objection holds that the Egyptians cannot have encoded π or φ because they possessed no such constants: there is no Egyptian word for either, and no surviving text treats them as abstract quantities. The premise is correct and the inference does not follow. Nothing in this section requires that the builders held an abstract constant, named it, or reasoned about it as the Greeks later did.

What it requires is that their own arithmetic produced the values, and that they used the arithmetic that does. A ratio does not need a name to be operative. A seked of 5 ½ palms yields a semi-perimeter-to-height relation of 22/7 (perimeter to height, 44/7) whether or not anyone present has a term for what 22/7 approximates, and the Wedjat fractions yield the correspondences documented above whether or not anyone present conceives of them as a numerical system. The claim advanced here concerns method, not vocabulary.

A point of evidence tells against reading the seked value backwards out of Egyptian circle mathematics. The Rhind Mathematical Papyrus gives an explicit rule for the area of a circle in Problem 50 — take eight-ninths of the diameter and square it — which corresponds to a π of 256/81, or 3.1605, in error by 0.602%. The value implied by a seked of 5 ½ is 22/7, or 3.14286, in error by 0.040%. The seked value is some fifteen times the more accurate. Whatever produced it, it was not derived from the circle rule the Egyptians actually wrote down, and the two are independent. This is consistent with the reading offered here: the accuracy resides in the fraction system and the proportions built from it rather than in any stated theory of the circle, which is what encoding through method rather than through doctrine would look like.

The objection does not, however, extend to the astronomical and calendrical correspondences, and the reason is visible within the comparative sample analysed above. Three of the nine documented pyramids share a seked of exactly 5 ½ palms: the Great Pyramid (base 440, height 280), Meidum (base 275, height 175), and Unas (base 110, height 70). All three therefore possess identical π-proportions and identical φ-proportions; whatever the seked confers, it confers equally on each. Their scores against the fourteen registered targets are 10 of 14, 7 of 14 and 7 of 14 respectively. A three-target spread separates monuments that the seked cannot distinguish at all.

The seked therefore explains π and φ, and explains nothing else. What varies across the three is the absolute dimension — 440 cubits against 275 and 110 — and it is the absolute dimension, operated on by the Wedjat fractions, that the astronomical correspondences track. This is also why the second Monte Carlo test varies base and seked jointly rather than slope alone: the discriminating variable is scale, not inclination. A reader who accepts the seked objection in full may treat π and φ as a single relationship rather than two, and may set them aside entirely, without touching the result on which this paper rests.

Table 1 below documents each primary dimension used in the mathematical encoding analysis, its measured value, measurement source, uncertainty range, and the check stated for it. These are comparisons with stated uncertainties or identities; no uncertainty propagation through the correspondences has been carried out.

Dimension	Measured Value	Source	Uncertainty	Claimed Correspondence	Basis stated
Base length	440 rc / 230.33 m	Dash (2012); Petrie (1883)	casing corners within ±0.10 m (Dash 2012)	π via perimeter÷height	Stated at ±0.5%; not propagated
Height (original)	280 rc (design) / 146.71 m (Petrie's measured 5776.0 in)	Petrie (1883, §144)	±7 in (±0.18 m)	π, φ via seked geometry	Stated at ±0.5%; not propagated
Slope angle (seked)	5.5 palms/cubit = 51°50′	Rhind Papyrus; Rossi (2003)	±2′	Seked-derived π and φ	Cited: Herz-Fischler (2000); not propagated

Dimension	Measured Value	Source	Uncertainty	Claimed Correspondence	Basis stated
Royal Cubit	0.5236 m	Lyons (1927: 135), derived from 440 rc; rods ~0.523 m (Zapassky et al. 2012)	not stated in the sources	π/6 m (arithmetic)	Yes — numerical proximity
Orientation	0.067° W of true N	Dash (2017); Nell & Ruggles (2014)	better than 4′ (Dash 2017)	Western processional axis	Directional claim; not an error test
KC north shaft	≈32.5°	Belmonte & Lull (2023); exact passage unchecked. Petrie (1883, §56, p. 83) reports a measured-section mean of 31°33′ for the part of the channel he could reach, not a whole-shaft mean	not stated in the sources	α Draconis at epoch	Cited: Trimble (1964); not propagated
KC south shaft	≈45° (Petrie 1883: about 45°13′)	Belmonte & Lull (2023); exact passage unchecked. Petrie (1883, §56, p. 83) reports a measured-section mean of 45°13′40″, likewise not a whole-shaft mean	not stated in the sources	Orion's Belt at epoch	Cited: Trimble (1964); not propagated

Declared Methodological Constraints

A note on evidence independence: the nine disciplines cited in this paper are not uniformly independent of one another. Mathematical analysis and archaeoastronomical analysis both operate on the same dimensional and survey data; their conclusions are correlated rather than independent confirmations. The genuinely independent evidence streams — those that could in principle falsify the hypothesis without reference to any other stream — are the genetic migration data, the paleohydrological reconstruction, the zooarchaeological assemblage analysis at Hierakonpolis, and the epigraphic transmission record. These four streams converge on the same geographic corridor and temporal window from entirely separate research programmes, without reference to pyramid dimensions or astronomical alignments. The convergence argument is strongest and most structurally independent in these four streams. The mathematical and archaeoastronomical streams constitute a

separate, internally coherent convergence argument that shares a data set with each other and should be evaluated on that basis.

To address the concern that a large search space makes pattern emergence statistically inevitable, the following constraints define the reproducible reanalysis reported here; the initial correspondences were identified before these constraints were fixed, as acknowledged below. They are stated here so any reader can replicate or challenge the search. Dimensions: six exterior measurements only — base (440 cubits), height (280 cubits), half-base (220 cubits), apothem (356.09 cubits), base diagonal (622.25 cubits), and perimeter (1,760 cubits) — all derived from Petrie (1883) and Dash (2012). No internal chamber dimensions are used in this section. Fractions: the exact six Wedjat fractions (½, ¼, ⅛, 1⁄16, 1⁄32, 1⁄64) and their sums only. No arbitrary fractions. No non-Wedjat denominators. Operations: multiplication and division only in the fixed-protocol reanalysis. Cross-dimension addition and subtraction — likewise attested in the Rhind Mathematical Papyrus — produce additional correspondences but are excluded from the statistical test to avoid inflating the expression space.

No higher-order transformations, no logarithms, no trigonometric functions. Threshold: results within 0.2% of a target value were recorded. All results — including non-matches — were reported. The post-hoc nature of this search is a genuine limitation, acknowledged throughout this section: the correspondences were identified before any protocol existed. The fixed-protocol reanalysis reported below is governed by an analysis protocol published alongside this paper, which fixes the target list, dimensions, fraction system, operations, tolerance, null models, decision rule and analysis code. That protocol converts the reported statistics into the application of a pre-specified procedure; it does not convert the original search into a confirmatory one, and does not claim to. The domain coherence of the results — that the constrained search recovers correspondences spanning all major Old Kingdom astronomical knowledge domains simultaneously — is the observation the hypothesis advances, not a statistical proof of encoding. The prospective comparative tests proposed in Predictions 6 and 7 define the methodological path toward confirmation or falsification of the encoding claim; Prediction 8 records a unit-specificity falsifier that has already been met.

Design specification rather than as-built measurement. The dimensions analysed throughout this section are the design values — a base of 440 royal cubits and a seked of 5 ½ palms — not the as-built measurements of the standing monument. This distinction matters and is stated explicitly. No Egyptian document records the figure 440; it is a reconstruction from survey. The surveyed base is 230.33 m as the mean of the Lehner–Goodman casing lengths (Dash 2012: 230.329 m, casing corners fixed within 10 cm) and about 230.35 m in Petrie's survey (9068.6 ± 0.4 inches, 1883, §143; mean of his four sides 230.348 m as tabulated in Dash 2012); at a royal cubit of 0.5236 m these convert to about 439.9 cubits. Petrie himself compared his measured base with 440 cubits of 20.620 inches (9073 ± 2 inches) and noted that the 440-cubit reading is supported by the height being 280 cubits (1883, §143); his original height is 5776.0 ± 7.0 inches against 5776.9 ± 1.1 inches for 280 cubits of 20.632 inches (§144). The 440-cubit reading rests on the following.

First, 440 is the nearest whole-cubit value: 439 and 441 cubits at 0.5236 m are 229.86 m and 230.91 m, about 0.47 m and 0.58 m from the Lehner–Goodman mean, against about 0.06 m for 440. Second, the result is stable across the full range of attested cubit lengths: values from 0.5232 to 0.5240 m yield 439.56 to 440.23 cubits at 230.33 m, rounding to 440 throughout. Third, and independently of the base, a base of 440 with a height of 280 yields a seked of exactly 5 ½ palms — a whole-and-half-palm design value of the kind documented in Rhind Mathematical Papyrus Problems 56–58 — producing a slope of 51.843°, within 0.002° of Petrie's measured 51 ° 50′ 40″. Two design parameters therefore resolve independently to simple Egyptian values. Because an encoding hypothesis is a claim about intent, and intent resides in the specification rather than in the executed stone, the design values are the appropriate object of analysis. The 0.023% divergence between the reconstructed specification and the surveyed monument combines reconstruction, metrological and execution considerations; the present analysis is conditional on the reconstructed specification. Readers should note that

correspondence counts computed on the surveyed value rather than the design value are lower, and that the analysis reported here is of the plan.

Per-target result. The table below gives every one of the fourteen targets with the single Wedjat operation that comes closest to it, the resulting value's error, and whether that error falls inside the ±0.2% threshold. Ten targets are reached and four are not: the sidereal month at 0.653%, the synodic month at 1.225%, Mercury at 0.684% and the Sothic cycle at 0.240%. The four misses are retained in the target list rather than removed, and the leave-one-out diagnostic reported below shows why that matters — deleting any miss improves the p-value, because a missed target adds nothing to the observed count while still raising the null's expected count, so a list from which failures had been pruned would score better and mean less. Every figure in the table is reproduced by the deposited analysis script. Whether the Wedjat system is specifically responsible for these ten, rather than any comparable set of small fractions, is not settled by this table; it is the question the system-specificity test addresses below, where each rival historical fraction system is downsampled to the Wedjat set's exact size and scored under identical rules.

Even-spacing control. One structural feature of the Wedjat system requires its own control. The six Wedjat signs combine additively — the notation in which Egyptian scribes wrote hekat capacities — and their sixty-three sums are exactly the sixty-fourths, k/64 for k = 1 to 63. That set is a perfectly uniform grid, whereas fraction sets drawn at random cluster and leave gaps, and a uniform grid covers a numerical range more efficiently than a clustered one. A null model built from randomly drawn fractions therefore sets a slightly lower bar than the Wedjat set faces. The test was accordingly repeated against fraction sets of the same cardinality and span, evenly spaced at the Wedjat grid's own spacing, with the placement of the grid randomly shifted; this isolates whether alignment on exact sixty-fourths matters, with spacing and cardinality held fixed. Under this more conservative null the Great Pyramid still exceeds the comparison systems, though at reduced significance: 10 of 14 against a mean of 6.00, which does not itself reach significance ($p = 0.055$), and 8 of 11 against 4.25 ($p = 0.031$); on the maximally-independent core the result likewise does not reach significance (6 of 9 against 3.39, $p = 0.100$). The reduced significance under this null is reported rather than omitted; the difference between the two sets of p-values is not interpreted here as a measured contribution of even spacing.

Denominator specificity. The even-spacing control raises the sharper question of whether the denominator 64 matters at all, or whether any sufficiently even grid would serve. This is testable deterministically by scoring the complete grids k/M against the same fourteen targets at the same threshold. Complete grids of the same construction score four to five: k/48 gives 4, k/60 gives 4, k/72 gives 5. The sixty-fourths give 10. The neighbouring denominators are not intermediate between these values; the transition is a discontinuity rather than a gradient, but the grids differ in cardinality (47, 59 and 71 fractions against 63) and in spacing, so this comparison does not separate the denominator from those properties. The denser grid k/128 scores 11 of 14, but with 127 fractions; a per-fraction comparison with the complete grid cannot establish superiority over equal-sized selections from it (see the sensitivity to comparator construction below), and 1/128 is not an attested Horus-eye sign — the series terminates at 1⁄64 — so k/128 represents a modern extension of the notation rather than a historical rival system. On this evidence the sixty-fourth grid scores higher than these three neighbouring complete grids; whether that reflects the denominator itself, grid spacing or cardinality is not separated by this comparison.

Target	Value (days unless noted)	Wedjat formula	Error
Anomalistic month	27.554	base × 4⁄64	0.196%
Sidereal month	27.322	base × 4⁄64	0.653% — miss

Target	Value (days unless noted)	Wedjat formula	Error
Synodic month	29.530	diagonal × 3⁄64	1.225% — miss
Civil year	365.000	base × 53⁄64	0.171%
Sidereal year	365.256	height ÷ 49⁄64	0.126%
360-day year	360.000	diagonal × 37⁄64	0.072%
70-day Sirius	70.000	height × 16⁄64	0.000%
Sothic cycle	1,461 yr	perimeter × 53⁄64	0.240% — miss
Saturn synodic	378.090	base × 55⁄64	0.009%
Jupiter synodic	398.880	base × 58⁄64	0.033%
Venus synodic	583.920	apothem ÷ 39⁄64	0.074%
Mars synodic	779.940	height ÷ 23⁄64	0.104%
Mercury synodic	115.880	diagonal × 12⁄64	0.684% — miss
Golden Angle	137.508°	base × 20⁄64	0.006%
TOTAL			10 of 14

Null Model and Statistical Framework

The following null hypothesis governs the statistical evaluation of this section.

H_0 (Null Hypothesis): The exterior dimensions of the Great Pyramid were determined by practical architectural, engineering, and cosmological considerations independent of systematic astronomical encoding through the Wedjat fraction system. Any mathematical or astronomical correspondences identifiable through Wedjat fraction operations are the product of coincidental numerical proximity within the search space.

H_1 (This Hypothesis): The exterior dimensions were chosen to preserve a structured body of mathematical and astronomical knowledge through the Wedjat fraction system. Under H_1, Wedjat fraction operations on the six primary exterior dimensions should produce correspondence rates with real astronomical and mathematical targets that significantly exceed chance, should exhibit structural patterns consistent with systematic domain-organised encoding, and should show selective absences consistent with the observational limits of the tradition described in The Corridor Series.

Predictions under H_0: Wedjat fraction operations on pyramid dimensions should produce correspondence rates with real astronomical constants statistically indistinguishable from randomly generated values in the same numerical ranges. Hits should be distributed randomly across domains without structural clustering by formula type or astronomical category.

Predictions under H_1: Correspondence rate with real targets significantly exceeds chance. Structurally related astronomical bodies share formula structures (e.g., same pyramid dimension and operation class). Hits cluster in domains with strong Egyptian observational tradition. Constants lacking that tradition (Mercury; modern physics constants) are absent or underrepresented.

Test and result: The constrained search (six declared dimensions × Wedjat binary fractions × declared operations, applied to fourteen astronomical and mathematical targets at ≤0.2% precision threshold) produces the correspondences documented throughout this section. Each correspondence is arithmetically verified. Taken individually, any single correspondence could be coincidental. Taken collectively, they span every major domain of Old Kingdom astronomical knowledge: all four of the visible planets tracked here, the anomalistic lunar month, multiple year types, and the complete Sirius-Osirian calendar cluster from 70 days to 1,461 years — all from the same six dimensions using the same Egyptian fraction system. The domain coherence of this pattern is the observation the hypothesis advances.

Structural evidence bearing on H_1: Saturn and Jupiter are both yielded by base × (Wedjat fraction) — the same pyramid dimension and the same operation, with different fractions for different bodies. Venus and Mars are yielded by apothem and height respectively, each divided by a Wedjat fraction — a consistent operation class for a different pair of bodies. Six mathematical constants are found, all Egyptian-constructible. Earth's two principal radii are recoverable through purely Egyptian-arithmetic formulae, at the lower evidential tier defined in the Earth's Geometry section. Mercury is not found, consistent with its observational difficulty. Euler's number, $\sqrt{3}$, and the speed of light are not found, consistent with their absence from any Egyptian observational tradition.

Interpretation and limitations: The search was conducted post-hoc rather than under a protocol fixed in advance, and the target list was compiled from astronomically meaningful values rather than randomly selected. These constraints prevent this section from constituting statistical proof of deliberate encoding, and that claim is not made here. What is presented is an observation: a constrained Wedjat-fraction operation on Giza's six declared exterior dimensions produces arithmetically verified correspondences spanning all major domains of Old Kingdom astronomical practice — planetary synodic cycles, lunar periodicity, solar and lunar calendrics, and the Sirius-Osirian ritual and long-period calendar system. The domain-complete pattern is the claim. Whether it reflects deliberate encoding is the hypothesis. The structural tests for that claim are stated as Predictions 6 and 7.

A note on the target list as constrained prior: the fourteen targets used in both Monte Carlo tests are not a random sample of astronomical quantities. They constitute a constrained prior — specifically, the periods and cycles that appear in the Egyptological record of Egyptian astronomical knowledge and practice: Neugebauer and Parker (1969, Egyptian Astronomical Texts Vol. III) document that the Egyptians tracked planetary synodic periods, decans, and stellar rising and setting cycles; Parker (1950) documents lunar and Sothic calendrics; the Rhind Mathematical Papyrus (c. 1550 BCE) documents the civil year and schematic year; the 70-day Sirius invisibility period is attested across multiple Old Kingdom and later sources. The Monte Carlo tests therefore ask a precise question: does the Wedjat fraction system specifically recover the documented Egyptian astronomical knowledge base? This is the correct question under H_1, because the hypothesis is that specifically Egyptian astronomical knowledge was encoded. A test using arbitrarily selected astronomical constants — including modern quantities unknown to the Egyptians — would be methodologically weaker, not stronger, because it would dilute the signal with noise. The fourteen targets are the signal. The fraction-system control test (Table 2) is the primary methodological control because it holds this target list constant and asks only whether the Wedjat system is doing the work — isolating fraction-system performance conditional on the selected target list, rather than establishing that the original target selection was unbiased.

The correspondences documented in this section were identified through a constrained post-hoc search. Their strength lies in their structural coherence and cultural alignment rather than in discovery under a protocol fixed in advance. The methodological constraints — six declared dimensions, six Wedjat fractions, two operations, and a 0.2% precision threshold — are designed to limit the search space and reduce the risk of spurious pattern-matching. The fraction-system control test (Table 2) and unit-system specificity test (Prediction 8) are the primary methodological controls for this section. Readers should weigh each correspondence against those constraints, and against the probability that

a domain-coherent, culturally aligned pattern of this density could arise from an unconstrained search of arbitrary numbers.

A further control addresses the concern that the fourteen targets, chosen after the correspondences were observed, might simply be values the framework can reach. In a target-value null, each target was replaced by a random value drawn from the plausible physical range of its own quantity type (a lunar period in 25–35 days, a planetary synodic in 100–800 days, a year-length in 300–400 days, and so on; the full ranges are given in the analysis protocol, §3.6d), and the Great Pyramid was scored against the resulting shadow list (N = 100,000, seed 42). At the baseline ±0.2% tolerance the pyramid reaches the real constants markedly more often than these random plausible values — 10 of 14 against a null mean of 6.25 ($p = 0.023$), 8 of 11 against 4.44 on the independent set ($p = 0.017$), and 6 of 9 against 3.53 on the maximally-independent set, which does not reach significance ($p = 0.064$) — indicating value specificity under this declared target-range null, not merely that the ranges are hittable. As with the other tests, the significance of the correspondence count is tolerance-dependent. The deposited code performs one tolerance sweep, on the matched-cardinality fraction null: it is significant at ±0.20% and ±0.25% and at the tightest ±0.05% step, and not significant at ±0.10%, ±0.15%, ±0.30% or looser. The target-value null reported here was run at the registered ±0.2% tolerance only; no tolerance profile is claimed for it. The chance baseline itself (approximately 6 of 14) reflects the density of the achievable-value set; the observed excess is real but modest, and is reported here alongside its tolerance profile rather than at a single favourable threshold.

The Mathematical Vocabulary: Correspondences with Fundamental Constants

The pyramid's slope is governed by a seked of 5.5 palms per cubit of rise — the ratio 14:11 in palm units. This is the single design decision from which all slope-derived correspondences follow. It is established in peer-reviewed Egyptology that the resulting proportions (height 280 cubits, base 440 cubits) yield a semi-perimeter-to-height ratio of 22/7 (perimeter to height, 44/7), an approximation of π with 0.040% error; the proportions themselves are given by Rossi (2003: 215–216). Herz-Fischler (2000) additionally notes that these approximations can arise naturally from the seked construction without requiring explicit knowledge of π and φ themselves — a position this hypothesis acknowledges: the seked choice produces the correspondences; whether that choice was made with awareness of its mathematical implications is the interpretive claim. It is similarly documented that the apothem — the slant distance from base midpoint to apex, derived by Pythagoras as $\sqrt{(220^2 + 280^2)} = 356.09$ cubits — divided by the half-base yields 1.61859, an approximation of φ with 0.034% error; this follows arithmetically from the stated dimensions. These two correspondences arise inevitably from the single choice of 280:220 and require no supplementary interpretation.

The following additional correspondences are presented as original observations within this hypothesis; no peer-reviewed source is known to have proposed them previously. Direct calculation shows that the exterior surface area ratios yield φ, φ−1, and φ² simultaneously from the same proportions — three area relationships converging on the golden ratio (algebraically interrelated, since $\varphi - 1 = 1/\varphi$ and $\varphi^2 = \varphi + 1$, and therefore not independent of one another) (errors 0.034%, 0.090%, 0.056% respectively). The base diagonal ($440\sqrt{2} = 622.25$ cubits) multiplied by the Wedjat fraction combination 23/64 and divided by 100 yields 2.23623, within 0.007% of √5. The height multiplied by the combined first three Wedjat fractions (7/8) and divided by 100 yields 2.45000, within 0.021% of √6. The base multiplied by the Wedjat combination 5/16 yields 137.500, within 0.006% of the golden angle ($360°/\varphi^2 = 137.508°$) — the angle at which successive elements in plant growth are positioned to achieve maximum exposure and minimum overlap. It governs the spiral packing of seeds in sunflower heads, scales in pine cones, and the unfurling of leaves along a stem across the plant kingdom. Any pastoralist community observing nature across generations would encounter this pattern daily. It is the smallest nonzero relative error among the fourteen targets (about 0.0058%; the 70-day relation is exact), and it is produced by one of the simplest Wedjat combinations: the second and fourth fractions summed, applied to the base. This hypothesis proposes its presence is consistent with a tradition that understood the mathematical grammar underlying natural growth — knowledge accumulated, as this

series argues, by a people who lived within and studied the natural world of the Green Sahara over millennia. The golden angle's mathematical necessity in plant growth is documented in peer-reviewed literature: Douady & Couder (1992, Physical Review Letters, 68:2098) demonstrated it as a self-organized physical process; Okabe (2015, Scientific Reports, 5:15358) demonstrated its biophysical optimality across vascular plants. A sustained pastoralist tradition across the Green Sahara would have encountered this pattern in the vegetation of their environment across millennia. This hypothesis proposes that these correspondences, taken together with the established π and φ relationships, suggest a mathematical vocabulary encoded in the pyramid's exterior geometry — the foundational constants from which measurement, proportion, and natural pattern can be reconstructed.

A note on Egyptian context: no surviving Egyptian text names the Golden Angle or the constant φ explicitly. The first formal definition of the 'extreme and mean ratio' appears in Euclid's Elements (c. 300 BCE), approximately 2,300 years after the pyramid was built. What the Egyptian mathematical record does document is the seked system: Rhind Mathematical Papyrus Problems 56–58 (c. 1550 BCE, copied from a 12th Dynasty original) show scribes computing pyramid slopes in palms per cubit. The Great Pyramid's seked of 5.5 palms per cubit produces a face angle of approximately 51.84°, which is close to a φ-proportioned structure (the apothem-to-half-base ratio is 1.6186, 0.034% from φ). The Golden Angle, $360°/\varphi^2$, is a function of φ, so a seked-derived ratio of 1.6186 gives about 137.4°, not 137.5°; the reported 440 × 5/16 = 137.5 correspondence depends on the absolute base of 440 royal cubits and does not follow from the seked alone. The Horus Eye fractions — the operational fraction set preserved in the papyri — are the same fractions this paper identifies as the pyramid's mathematical vocabulary (Clagett 1999; Robins & Shute 1987; Imhausen 2006). Whether the Golden Angle was a deliberate encoding or an emergent property of seked-based construction cannot be resolved from surviving sources. Its presence in the dataset is reported as a geometric observation, registered with the smallest nonzero relative error among the fourteen targets (about 0.0058%).

The Unit of Measure

The Royal Cubit estimated from surviving cubit rods and marked vessels is about 0.523 m (Zapassky et al. 2012: ~52.3 cm); Rossi (2003, Table 2) gives c. 52.5 cm. The value 0.5236 m, which lies within 0.0002% of π/6, is printed by Lyons (1927: 135), who derived 0.5236 m and 0.5235 m from surveyed pyramid sides on the assumption that the side was 440 royal cubits. It is therefore a pyramid-derived estimate, not an independent rod-derived standard, and cannot serve as independent evidence for the 440-cubit reading. The 0.0002% figure describes how close the rounded value 0.5236 is to π/6, not the survey: dividing the surveyed base by 440 gives 0.52348 m (Lehner–Goodman mean, Dash 2012), 0.52352 m (Petrie) and 0.52353–0.52358 m (Cole's survey as reported by Lyons 1927), which lie 0.004–0.024% from π/6 (0.523599 m). Petrie's own determination from the Great Pyramid is larger, 20.632 ± 0.004 inches or about 0.5241 m (Petrie 1883, from the King's Chamber), so the π/6 proximity is a property of the 0.5236 m value rather than of Petrie's survey figure. The proximity of 0.5236 m to π/6 m is a modern metrological comparison, not a recovery procedure. A dimensionless ratio cannot by itself recover an absolute length: recognising π and dividing by six yields a number, not a physical standard, and a pyramid of any size preserves the same ratios. Recovering the unit would require an independently specified length reference, which this paper does not supply.

Cardinal Orientation and the Wedjat Fraction of the Circle

It is established that the Great Pyramid's four exterior faces are oriented to the cardinal directions to within about 4 arc minutes, one of the most precise alignments known from the ancient world (Dash 2017; Spence 2000). Expressed as fractions of a full circle: each face-to-face angle is 90° = one quarter of 360°; the face diagonals bisect at 45° = one eighth of 360°; the north-south axis spans 180° = one half of 360°. These are precisely the second, third, and first Wedjat fractions (¼, ⅛, and ½ respectively). Separately, Belmonte (2001) has documented in peer-reviewed archaeoastronomical literature that Egyptian temple orientations systematically employed rotations of ⅛, ¼, and ½ of a full circle — the same three fractions — as a hierarchical orientation system across multiple construction

periods. This hypothesis proposes that the pyramid's precisely achieved cardinal alignment is consistent with the same Wedjat fraction system governing orientation as well as dimension — that the structure's spatial position in the landscape was oriented by the same mathematical framework that this hypothesis proposes governs its dimensional encoding. The Belmonte pattern provides independent peer-reviewed evidence that these specific angular fractions were architecturally functional in Egyptian construction practice.

Correspondences with Earth's Geometry

Direct calculation confirms the following mathematical relationships, presented here without claiming their intentionality is established. All comparisons here are computed in royal cubits — the unit in which the pyramid was designed and built — with metric values given in parentheses only for the reader's reference, since the metre is a modern unit the builders did not use. At the value of 0.5236 m per royal cubit (Lyons 1927: 135), Earth's polar radius is 12,140,474 cubits (6,356.752 km, WGS84) and its equatorial radius is 12,181,316 cubits (6,378.137 km). Both principal radii are recoverable using only components attested in Egyptian practice. The sum of the base and its diagonal, multiplied by 10,000 (an attested decimal power with its own hieroglyph) and divided by the Wedjat sum 7/8 (= ½ + ¼ + ⅛), yields 12,140,045 cubits (6,356.528 km), within 0.0035% of Earth's polar radius. The sum of the height and the diagonal, multiplied by the 360-day schematic year, by 100, and by the Wedjat sum 3/8 (= ¼ + ⅛), yields 12,180,429 cubits (6,377.672 km), within 0.0073% of Earth's equatorial radius. No modern constant enters either formula. Earth's two principal radii differ by approximately 40,842 cubits (21 km) because Earth is an oblate spheroid, not a perfect sphere. Two limitations designate this observation as a lower evidential tier than the registered fourteen-target suite. First, these formulae expand the operation class: pairwise sums of dimensions and calendrical multipliers do not appear in the fourteen-target Monte Carlo analysis, whose statistics this subsection therefore cannot inherit. Second, under the denser combinatorial grid this expansion creates, closeness of this order is not rare: random targets of the same magnitude are matched at comparable precision (median best-error ≈ 0.009%; Monte Carlo control, N = 50,000, seed 42). The correspondence is accordingly presented as a demonstration of possibility within Egyptian arithmetic — the terrestrial radii are expressible in the builders' own numerical system to high precision — not as a statistically distinctive encoding. Whether a more constrained Egyptian route exists that would make the terrestrial match as rare as the planetary ones remains an open question.

Correspondences with Lunar and Solar Cycles

The following correspondences are original observations within this hypothesis. Direct calculation shows that the base multiplied by the fourth Wedjat fraction (1⁄16) yields 27.5 days, within 0.196% of the anomalistic lunar month (27.554 days). The apothem added to the fifth Wedjat fraction of the height (1⁄32 × 280 = 8.75) yields 364.840 days, within 0.044% of the Egyptian civil year of 365 days; this formula was independently verified by arithmetic computation (see AI Use Disclosure). The base minus the height multiplied by the Wedjat combination 17/64 (= ¼ + 1⁄64) yields 365.625 days, within 0.101% of the sidereal year (365.256 days). In the modern account of the Wedjat myth associated with Gardiner (1927: 197) — an explanation for which no Egyptian text is cited here — the fraction 1⁄64 is Thoth's restoring portion; Thoth is specifically the Egyptian deity of time measurement and the lunar calendar (Wilkinson 2001). This hypothesis notes this thematic convergence while acknowledging it cannot substitute for evidence of intent.

Two additional correspondences connect the exterior dimensions to the Sirius-centred timekeeping system. First, the 360-day schematic year: the base of the Egyptian civil calendar was twelve months of thirty days each — 360 days before the five epagomenal days were added — and this administrative foundation appears throughout the Rhind Mathematical Papyrus. The half-base (220 cubits) added to the height multiplied by the primary Wedjat fraction (½ × 280 = 140) yields 220 + 140 = 360.000 days exactly — the simplest addition formula in the dataset, using two dimensions and the largest Wedjat fraction. Second, the 70-day period of Sirius invisibility: Sirius was absent from the

night sky for approximately 70 days each year as seen from the Giza latitude, a period the Egyptians encoded as the canonical duration of mummification and directly associated with the death of Osiris and the mourning of Isis (Neugebauer & Parker 1969). The height of the pyramid (280 cubits) multiplied by the second Wedjat fraction (1⁄4) yields 70 days exactly. This is the simplest possible correspondence in the entire dataset — a single dimension and a single fraction — yet it connects the pyramid's height to the star whose alignment the Queen's Chamber southern shaft encodes and whose long cycle the Sothic correspondence below encodes.

Proposed Correspondences with Planetary Synodic Periods

The correspondences presented in this subsection are original mathematical observations within this hypothesis. No peer-reviewed source is known to have previously proposed that the Great Pyramid's exterior dimensions encode planetary synodic periods through Wedjat fraction operations. Readers are asked to evaluate these as candidate correspondences, not established encodings. It is documented that the ancient Egyptians tracked planetary motions: Neugebauer & Parker (1969, Egyptian Astronomical Texts Vol. III) provide the standard scholarly edition of Egyptian texts recording decans, planets, and zodiacs, establishing that sustained planetary observation was part of the Egyptian astronomical tradition. This hypothesis proposes that synodic periods accumulated through that observational tradition are preserved in the pyramid's exterior dimensions through the Wedjat system. Direct calculation confirms the following. Saturn (synodic period 378.09 days): base × (55/64) = 378.125 days, within 0.009%. Jupiter (398.88 days): base × (29/32) = 398.750 days, within 0.033%. Venus (583.92 days): apothem ÷ (39/64) = 584.353 days, within 0.074%. Mars (779.94 days): height ÷ (23/64) = 779.130 days, within 0.104%. All four fractions are confirmed exact sums of distinct Wedjat parts. All four results were independently verified by arithmetic computation (see AI Use Disclosure).

This hypothesis proposes that the structural pattern of these correspondences — Saturn and Jupiter both yielded by base × (Wedjat fraction), sharing a formula structure across related bodies; Venus and Mars yielded by apothem and height respectively through division — is more consistent with systematic encoding than with chance. A systematic search across all formula combinations at the same precision threshold was conducted; Mercury was not found within acceptable error bounds. The structural patterning — Saturn and Jupiter sharing a formula family, Venus and Mars sharing the division operation — is noted as consistent with systematic encoding. Mercury was not found within the 0.2% threshold; this absence is reported as a genuine null result.

Proposed Stellar Cycle Correspondence: The Sothic Period

The Sothic cycle is the longest practical astronomical period the Egyptians are documented to have tracked. Because the civil year of 365 days is shorter than the true solar year by approximately 0.25 days, the heliacal rising of Sirius (the calendar anchor of Egyptian civilisation) drifted through the civil calendar, completing a full 365-day drift and returning to its original calendar date after 1,461 civil years. This is the Sothic cycle — a conventional idealised duration of 1,461 civil years — roughly fifty to sixty generations at an assumed 25–30 years per generation, directly observable through sustained astronomical record-keeping, and documented as culturally significant in Egyptian inscriptions across multiple periods. The connection between the Sothic cycle and the civil year's 0.25-day annual drift makes it, in effect, the long-term correction cycle for the 365-day calendar: the civil year encodes the daily timekeeping; the Sothic cycle encodes the multi-generational recalibration. A methodological note on evidentiary framing: the 1,461-year period is the arithmetic consequence of the civil calendar's own structure — 365 days of drift at one day every four years, counted in the 365-day civil year itself — derivable by any tradition that tracked the Sothic rising against the civil calendar and noted the annual drift rate. Both the Kahun Papyrus (c. 1825 BCE) and the Ebers Papyrus document Egyptian observation of Sothic risings against the civil calendar (Parker 1950); whether Old Kingdom astronomers named the 1,461-year period explicitly or possessed the annual observations from which it is arithmetically calculable, the correspondence proposed here encodes the mathematical foundation of the calendar system itself. This framing makes the claim more defensible: it does not

require a named Old Kingdom Sothic doctrine, only the annual record-keeping already documented in the papyri. This hypothesis proposes that the perimeter of the Great Pyramid, multiplied by the Wedjat combination ½ + ¼ + 1⁄16 + 1⁄64 (= 53/64), yields 1,457.5 years, 0.240% from the cycle's 1,461 civil years. The Wedjat sum 53/64 uses four of the six fractions (the first, second, fourth, and sixth); it is arithmetically straightforward in Egyptian grain-measurement terms. That error falls outside the ±0.2% threshold used throughout this section, so the Sothic cycle is one of the four targets recorded as a miss in Table 2 and is excluded from the scored count. It is the only exterior dimension that reaches the order of a known long-period stellar cycle at all, and it stands alongside the Queen's Chamber shaft alignment with Sirius and the 70-day invisibility period documented above, which converge on the same astronomical object within tolerance.

Calendar and Sirius Cluster: Summary

The three correspondences above form a coherent Sirius-centred cluster. The 360-day schematic year is the administrative and mathematical foundation of the civil calendar — the base structure before the five epagomenal days are added — encoded exactly as half-base + height × ½ = 360.000 (an addition-based correspondence, excluded from the × / ÷ statistical test, which reaches the 360-day year separately). The 70-day invisibility period is the annual ritual anchor of the Osirian mythology, the canonical duration of mummification. The Sothic cycle is the multi-generational correction period that closes the drift between the 365-day civil year and the stellar year anchored by Sirius. Together with the existing civil and sidereal year correspondences already documented in this section, they demonstrate that the pyramid's exterior dimensions preserve the full layered structure of Egyptian calendrical astronomy — from administrative practicality (360-day base), to annual ritual theology (70-day Sirius absence), to long-period stellar recalibration (Sothic cycle). This is the only cluster in the dataset where three arithmetical relations (two within tolerance, one outside it) converge on a single astronomical object through three different dimensional mechanisms, though only the 70-day period falls inside the × / ÷ statistical test: the 360-day relation is addition-based and the Sothic relation falls outside the tolerance: half-base and height combined (360-day), height alone (70-day), and perimeter (Sothic cycle). The cluster is powerful precisely because it is not imposed: each of the three correspondences was identified independently, uses a different combination of the pyramid's dimensions (the perimeter is itself eight half-bases, so the dimensions are not mutually independent), and encodes a different time-scale of the same stellar phenomenon — daily structure, annual ritual, and multi-generational recalibration — spanning from 70 days to 1,461 years.

Calendar Coherence: The Wedjat Sum as Lunar Reconciliation Key

A second-order observation distinct from the direct dimensional correspondences above emerges from the 360-day schematic year already encoded in the pyramid's proportions. The complete Wedjat sum (63/64) applied to the 360-day schematic year yields 354.375 days — within 0.002% of the lunar year (12 × 29.530588 ≈ 354.367 days). This is not a dimensional encoding: no single pyramid dimension multiplied by a Wedjat fraction produces the lunar year within the 0.2% threshold of the Monte Carlo analysis. It is instead a property of the Wedjat system applied to an already-encoded constant, demonstrating that the fraction system is internally coherent with Egyptian calendar reconciliation practice. Parker (1950) documents that the Egyptians maintained a lunar religious calendar alongside the administrative calendar continuously from the Old Kingdom onward; the Kahun Papyrus (c. 1800 BCE) and the Ebers Papyrus calendar correlate both systems in a single document.

The operation is equivalently expressed as the 360-day year minus the 1⁄64 that the modern account assigns to Thoth: 360 − (360 × 1⁄64) = 354.375 days. The 1⁄64 fraction — 5.625 days annually — approximates the actual drift between the schematic and lunar calendars (5.633 days per year, error 0.14%). In the modern account of the Wedjat myth, 63/64 is the damaged eye: what remains after Set's fragmentation. The 1⁄64 is read, on that account, as Thoth's restoring portion: the knowledge required to complete what was broken. In the calendar, the lunar year is the damaged state — 63/64 of the administrative whole — and every year Thoth's 1⁄64 marks the drift that must be tracked to keep the religious and administrative calendars in alignment. The pyramid encodes not only the 360-day

administrative year in its dimensions but the lunar religious calendar as a consequence of that encoding, mediated by the same fraction system used to measure grain and calculate construction slopes.

The 64-year cycle that follows requires no precision threshold: 64 × (360/64) = 360 exactly. Within the schematic model, 64 annual deficits of 360/64 days sum exactly to one full 360-day year. Against the adopted mean lunar year (twelve lunations of 29.530588 days, 354.367 days) the 64 annual differences total about 360.508 days, so this is an approximate reconciliation rather than an exact astronomical return. The Wedjat denominator (64) is the length of the complete cycle in the schematic model. The system is self-referential: the fraction with the largest denominator (1⁄64) produces the annual drift, and the denominator itself is the number of years before the drift closes and the cycle returns to its origin. This relationship is proposed here as a hypothesis consistent with documented Egyptian calendar practice; it connects the administrative, religious, and mathematical domains of the pyramid's encoding through a single arithmetic property of the Wedjat fraction system.

Correspondence	Dimension & Formula	Result	Error	Egyptian Significance
360-day schematic year	Half-base + Height × ½ (220 + 280×½)	360.000 days	0.000% (exact)	Administrative and mathematical foundation (Rhind Papyrus); 12 × 30 base structure
70-day Sirius invisibility	Height × ¼	70.0 days	0.000% (exact)	Mummification canon; Osiris/Isis ritual cycle; canonical Sirius absence period
Sothic cycle	Perimeter × 53/64 (½ + ¼ + 1⁄16 + 1⁄64)	1,457.5 years	0.240% — outside the ±0.2% tolerance	Long-term calendar recalibration; heliacal rising of Sirius returning to civil calendar date after 1,461 civil years

The Stellar Timestamps: Published Stellar Interpretations and Proposed Dating

Published stellar interpretations (Badawy 1964; Trimble 1964) associate the King's Chamber shafts with candidate stars near the construction epoch. Trimble (1964) proposed an astronomical function for the King's Chamber shafts. The King's Chamber southern shaft (approximately 45°) targeted Orion's Belt as a constellation-level astronomical object, a reading proposed by Badawy (1964). The shaft angle of ~45°13' (Petrie 1883) falls within the culmination range of Orion's Belt at the construction epoch; the correspondence is to the constellation of Osiris as a whole, consistent with the Pyramid Texts' language throughout. A further line of support for the Canopus-proxy argument emerges from classical sources: Plutarch (De Iside et Osiride, Moralia 359E) documents that the Egyptians identified the constellation Argo Navis — whose brightest star is Canopus — as the Boat of Osiris. Osiris was therefore associated with two stellar forms simultaneously: Sah/Orion as his constellation-body accessible from northern latitudes, and the Boat of Osiris/Canopus-Argo as his southern stellar identity at the limit of visibility. The King's Chamber south shaft encodes the accessible Osirian constellation at 45°; Canopus, the Boat of Osiris, culminated at only about 4.5° at 30°N (computed in the Wedjat as Portable Celestial Map section below). On the reading proposed here, the shaft therefore corresponds to the accessible component of a dual Osirian identity, whose other component stood close to the southern horizon at Giza's latitude. The northern shaft (approximately 32°) aligned to Alpha Draconis, the then-pole star (Trimble 1964). The Queen's Chamber southern shaft aligned to Sirius, whose heliacal rising (prt spdt) was an important marker of

the Egyptian year, though it wandered through the civil calendar over a Sothic cycle of about 1,460 years (Belmonte 2009; Belmonte & Lull 2023). Spence (2000, Nature 408:320–324) dated the start of construction to c. 2,480 BCE by a different route — modelling the precession of the simultaneous meridian transit of Kochab (β Ursae Minoris) and Mizar (ζ Ursae Majoris) against the cardinal orientation errors of successive Old Kingdom pyramids, not from the shaft angles. Her result has been contested on methodological grounds (Rawlins & Pickering 2001; Belmonte 2001) and is cited here as one dating model among several. The proposed stellar correspondences can constrain candidate epochs conditional on the selected targets, channel measurements and precession model. Their interpretation as an intentional self-dating device is this paper's hypothesis. Within the framework of this hypothesis, this is interpreted as a self-dating feature — the monument records not only knowledge but the epoch in which it was deposited.

Concavity and a Proposed Equinox Indicator

It is documented that the Great Pyramid has concave stone faces (Nell & Ruggles 2014, pre-print version). Petrie (1883: 43–44) reports hollowing of the core masonry and a groove down the middle of the face, estimates the whole of the hollowing at 37 on the north face (Petrie prints no unit on that line; the figures around it are in inches, so about 940 mm), and infers extra casing thickness along the midline; Maragioglio and Rinaldi report a marked, apparently intentional concavity in the packing blocks of Menkaure's pyramid as well (quoted by Nell & Ruggles 2014, pre-print version). Damiani (1991: 96–99), adopting a hollow of 0.92 m at the midpoint of each base side that he attributes to Pochan (1971), models the illumination transitions that such a hollow would produce on each face as the Sun's path crosses the face planes, and identifies the coincidence of the north- and south-face transitions at the equinoxes, at sunrise and sunset, as a possible calendrical signal. Transitions on individual faces also occur on other dates, and he reports a coincidence of two faces on about 4 March and 8 October as well. This supplies a published geometric model for the proposed solar-calendar interpretation; it does not establish that the builders intended or used the feature as an instrument. This paper proposes the concavity as a passive solar-calendar indicator of the equinoxes; that reading is a proposal. The observed hollowing of core or packing masonry does not by itself establish the precise geometry of the original finished casing; the proposed illumination signal therefore remains conditional on the adopted face geometry. Damiani's separate conjecture of a gnomon on the summit is not adopted here. A claim in popular circulation — that the concavity depth encodes Earth's curvature — was directly tested and refuted: Earth's surface curvature across 230 metres produces a sag of approximately 1 mm; the concavity depth is 940 mm, a factor of 903 larger. This claim is not supported by calculation and is not advanced here.

The Encoding System: The Wedjat as the Proposed Key

The Wedjat fraction system — ½, ¼, ⅛, 1⁄16, 1⁄32, 1⁄64, summing to 63/64 with the missing 1⁄64 supplied, in the modern account of the myth, by Thoth (Gardiner 1927: 197) — is documented in peer-reviewed Egyptology as the Egyptian system of binary measurement, appearing in the Rhind Mathematical Papyrus and in medical and administrative contexts from the Fifth Dynasty onwards (Clagett 1999; Pommerening 2003). It is further documented by Belmonte (2001) that this fraction system governed temple spatial orientations. This hypothesis proposes — and cannot at this stage prove — that the Wedjat also served as the decoding key for the correspondences documented in this section. Without the Wedjat, these correspondences are invisible in the pyramid's dimensions. With it, a structured pattern emerges across multiple astronomical and mathematical domains. This hypothesis interprets that emergence as evidence of design.

Summary Table of Correspondences

Table 2 presents every documented correspondence. The "Status" column distinguishes established findings (supported by independent peer-reviewed literature), verified mathematical relationships (arithmetically confirmed, no prior peer-reviewed precedent for deliberate encoding), and original

proposals within this hypothesis. Operation class is marked where it differs across entries. Formulae tagged ×÷ fall inside the fixed-protocol reanalysis; those tagged addition or subtraction use the cross-dimensional operations attested in the Rhind Mathematical Papyrus but deliberately excluded from the Monte Carlo test, as declared in the Declared Methodological Constraints. Where a target is reachable by both operation classes the two routes differ, and the statistical test reports the ×÷ route even where it carries the larger error — the civil year at 0.171% by base×(53/64) rather than 0.044% by addition, and the sidereal year at 0.126% by height÷(49/64) rather than 0.101% by subtraction. The statistics therefore rest on the more conservative figures, and a reader comparing this table with the Statistical Appendix should expect the two to differ for those entries.

Established (peer-reviewed) | Constructibility: Egyptian mathematics or direct observation — π via seked: 3.14286, error 0.040% (arithmetic from the stated proportions; Verner 2001, unchecked) | φ via apothem: 1.61859, error 0.034% (arithmetic from the stated dimensions) | Royal Cubit ≈ π/6 m = 0.5236 m (Lyons 1927: 135, pyramid-derived) | Cardinal orientation about 4′ (Dash 2017; Spence 2000) | Published stellar interpretations: King's Chamber — Orion and Alpha Draconis (Badawy 1964; Trimble 1964); the Queen's Chamber southern shaft and Sirius are discussed separately above | Concavity (Petrie 1883) and its proposed equinox illumination signal (modelled by Damiani 1991).

Verified mathematical correspondences, no prior peer-reviewed precedent for deliberate encoding — [Egyptian constructible: derivable from seked, Wedjat, and Pythagorean methods] φ area triple (φ, φ−1, φ² from exterior areas, errors 0.034%/0.090%/0.056%) | √5 via diagonal×(23/64)/100, error 0.007% | √6 via height×(7/8)/100, error 0.021% | Golden angle via base×(5/16), error 0.006% | [Requires carried knowledge: only meaningful if Earth's dimensions were known] Earth polar radius via (base+diagonal)×10,000÷(7/8), error 0.0035% | Earth equatorial radius via (height+diagonal)×360×100×(3/8), error 0.0073% [lower tier: Egyptian-arithmetic recoverability; see Correspondences with Earth's Geometry] | [Observationally accessible: derivable from sustained sky-watching] Anomalistic month via base×(1⁄16), error 0.196% [×÷ — in the statistical test] | Civil year via apothem+height×(1⁄32), error 0.044% [addition — outside the statistical test] | Sidereal year via base−height×(17/64), error 0.101% [subtraction — outside the statistical test].

Original proposals within this hypothesis [Requires carried knowledge: only meaningful if these cycles were observationally recorded] — Saturn (378.09d): base×(55/64) = 378.125d, error 0.009% | Jupiter (398.88d): base×(29/32) = 398.750d, error 0.033% | Venus (583.92d): apothem÷(39/64) = 584.353d, error 0.074% | Mars (779.94d): height÷(23/64) = 779.130d, error 0.104% | Mercury: not found.

What Was Explicitly Tested and Not Found

In the interest of transparency, the following were explicitly tested and not found, or were found and refuted. Speed of light: refuted. The claim is that the Great Pyramid stands at latitude 29.9792458°N and that the speed of light in vacuum is 299,792,458 m/s. The correspondence fails on four independent grounds. First, and decisively, the pyramid is not a point: its 230.33 m base spans 0.00208° of latitude — 7.48 arcseconds — so the monument occupies every latitude from 29.97821°N to 29.98028°N. Roughly twenty thousand distinct seven-decimal latitude values intersect the structure, and the digits beyond the third decimal place are therefore not a property of the monument but a choice of which point on it is measured. Second, the quoted line does not pass through the apex, which lies at approximately 29.9791750°N, some eight metres to the south. Third, the figure 299,792,458 is not a measured quantity but a definition: since the 17th General Conference on Weights and Measures (1983) the metre has been defined as the distance light travels in 1/299,792,458 of a second, the digits having been selected to preserve the length of the metre established by the French meridian survey of the 1790s. The number is an artefact of modern metrological convention. Fourth, the comparison equates a value in degrees with a value in metres per second, which requires disregarding both the decimal point and the units. The finite speed of light was itself not established until Rømer (1676). This correspondence is accordingly recorded here as refuted, not merely unconfirmed. Euler's number e: systematic search of all primary dimension ratios

found nothing within 0.5% of e = 2.71828; a formula in popular circulation claimed to yield e but in fact yields φ, a misidentification. Sidereal year in the base: the base measures 440 Royal Cubits; 365 cubits × 0.5236 m falls approximately 39 metres short of the actual base in every standard Egyptian unit system. Earth's curvature encoded in the concavity: calculation shows the concavity is 903 times too deep for Earth's surface curvature across 230 m. Mercury's synodic period: not found within acceptable error bounds after systematic search. √3, √7, the Euler-Mascheroni constant, and ln 2: not found within 0.3% after systematic search.

Independent Arithmetic Verification

All findings in this section were independently verified by arithmetic computation, beginning from a sceptical position. The initial objection that φ had a larger error than π was resolved after direct calculation confirmed it. The planetary correspondences, the year-from-apothem formula, and the Earth radii relationships were each independently computed and confirmed. Two conclusions emerged from verification: that mathematics alone cannot establish intent, and that a fully controlled search protocol fixed in advance and applied to a comparison dataset of comparable monuments would strengthen the statistical argument. Both are reflected in the framing throughout this section. The AI tools used in this verification are disclosed in the AI Use Disclosure. The mathematical relationships documented here are verified; the interpretation is hypothesis.

The Proposed Scope of the External Memory

If the correspondences documented in this section are accepted as deliberate — and this hypothesis proposes that they are, while acknowledging that this is a claim requiring ongoing scrutiny and eventual peer review — then what may be preserved in the pyramid's exterior spans seven independent knowledge domains, comprising a mathematical vocabulary (π, φ, √5, √6, the golden angle, and the Royal Cubit as their practical embodiment); the physical scale of the Earth in both its principal dimensions (at a designated lower evidential tier); the Moon's anomalistic cycle; the Sun's civil and sidereal year, together with the 360-day schematic base and a proposed equinox indicator in the exterior geometry; the synodic periods of four of the five planets visible to the naked eye; the Sothic cycle connecting the 365-day civil year to its long-term stellar recalibration; and the 70-day period of Sirius invisibility linking the pyramid's height to the embalming canon and Osiris mythology. The shaft angles additionally encode the sky's stellar configuration at the construction epoch, enabling precession-based dating by any future observer who knows the precessional rate. Of these, the fourteen registered targets (astronomical, calendrical and the golden angle) — and only those — were submitted to the Monte Carlo analysis, of which ten are reached within the registered tolerance (Test 1, p = 0.01497). Apart from the golden angle, the mathematical constants and the terrestrial radii were not among the registered targets and carry no Monte Carlo support.

This hypothesis does not claim these correspondences constitute proof of deliberate encoding. It proposes that their precision, domain coherence, structural consistency, verified presence of absences (Mercury, e, √3), and alignment with the documented domains of the Wedjat fraction system — a system independently attested in Egyptian mathematical, medical, architectural, and calendrical practice — make deliberate encoding the more parsimonious explanation. The Corridor Series establish the who, where, and why of the transmission. This section documents the what: the domains of knowledge that the exterior of the pyramid may have been built to carry. The internal structure of the pyramid, with its own proposed encoding, lies outside the scope of this paper.

Table 3. Verified Wedjat Correspondences: Complete Arithmetic

Operation class, as in Table 2: the golden angle, anomalistic month, Saturn, Jupiter, Venus, Mars and Sothic cycle entries use multiplication or division only and fall inside the fixed-protocol reanalysis. The civil year, sidereal year and 360-day year entries use cross-dimensional addition or subtraction, attested in the Rhind Mathematical Papyrus but excluded from the Monte Carlo test; where a target is reachable by both classes the statistical analysis reports the multiplication or division route, which for

those three targets carries the larger error. The 70-day Sirius entry uses multiplication and is inside the test.

Target	Formula (Royal Cubits)	Result	Target value	Error
Golden Angle (137.508°)	440 × (5⁄16) = 440 × 0.3125	137.500	137.508°	0.0058%
Anomalistic month (27.554 d)	440 × (1⁄16) = 440 × 0.0625	27.500	27.554 d	0.1960%
Civil year (365.000 d)	356.09 + 280 × (1⁄32)	364.840	365.000 d	0.0439%
Sidereal year (365.256 d)	440 − 280 × (17⁄64)	365.625	365.256 d	0.1010%
360-day year (360.000 d)	220 + 280 × ½	360.000	360.000 d	0.0000%
70-day Sirius (70.000 d)	280 × ¼	70.000	70.000 d	0.0000%
Saturn (378.09 d)	440 × (55⁄64)	378.125	378.09 d	0.0093%
Jupiter (398.88 d)	440 × (29⁄32)	398.750	398.88 d	0.0326%
Venus (583.92 d)	356.09 ÷ (39⁄64)	584.353	583.92 d	0.0741%
Mars (779.94 d)	280 ÷ (23⁄64)	779.130	779.94 d	0.1038%
Sothic cycle (1,461 yr)	1,760 × (53⁄64)	1457.500	1,461 yr	0.2396% (miss)

What Was Ultimately Built

The Wedjat as a Portable Celestial Map and the Pyramid as a Fixed Anchor

The Wedjat sky-compass as a portable celestial map is fully documented in Corridor II (Levy 2026b, Section 5). Canopus — whose Egyptian identification remains open, with Shaltout, Belmonte and Fekri (2007) proposing, as a possibility they explicitly flag for further study, that it is the Great Star (sb3 '3) of Pyramid Texts Utterance 882 that traverses the sky with Sah, and with classical sources identifying its constellation Argo Navis as the Boat of Osiris (Plutarch, De Iside et Osiride, Moralia 359E; discussed below); for Canopus as an orientation target in Egyptian sacred architecture see Belmonte, Pérez Die and Díaz-Iglesias Llanos (2016) — stood progressively lower at each step northeast at any one date. At the Richat Structure (21.1°N), Canopus was a consistent visible feature. At Giza (30.0°N), during the pyramid-building era (~2570 BCE), Canopus culminated at approximately 4.5° — horizon-grazing. The visibility limit for Canopus at approximately 5500 BCE was 27.7°N;

precession lifted this limit gradually northward, reaching ~34.5°N by pyramid-building time. Canopus was below the horizon at the Giza plateau's latitude of 30°N during the Green Sahara peak and lay near the northern edge of the star's practical visibility zone by the Old Kingdom.^[Altitudes calculated using the precession model documented in Corridor II (Levy 2026b, Appendix A).]

A foundational study by Alexander Badawy and astronomer Virginia Trimble first proposed that the so-called air-shafts in the King's Chamber were orientated to the stars of Orion's Belt (Osiris) in the south and to the circumpolar stars (Alpha Draconis) in the north (Badawy 1964; Trimble 1964). This paper proposes the pyramid encodes the stars of the Saharan ancestral tradition — but at Giza latitudes, a shaft aimed at Canopus would have run nearly horizontal across the pyramid's mass (calculation below). The geometry supplies a mechanism, not a record of the builders' decision. At 30°N and ~2570 BCE, Canopus's declination of approximately −55.5° gives it a maximum altitude above the southern horizon of approximately 4.5°. All Canopus altitudes quoted in this paper derive from a single computation rather than being calculated separately at each point of use. The method is stated here in full: J2000.0 catalogue position with proper motion, Vondrák et al. (2011) long-term precession, altitude at upper culmination as 90° − latitude − |declination| (geometric, without refraction; extinction is treated separately as apparent magnitude, following Schaefer 1998).

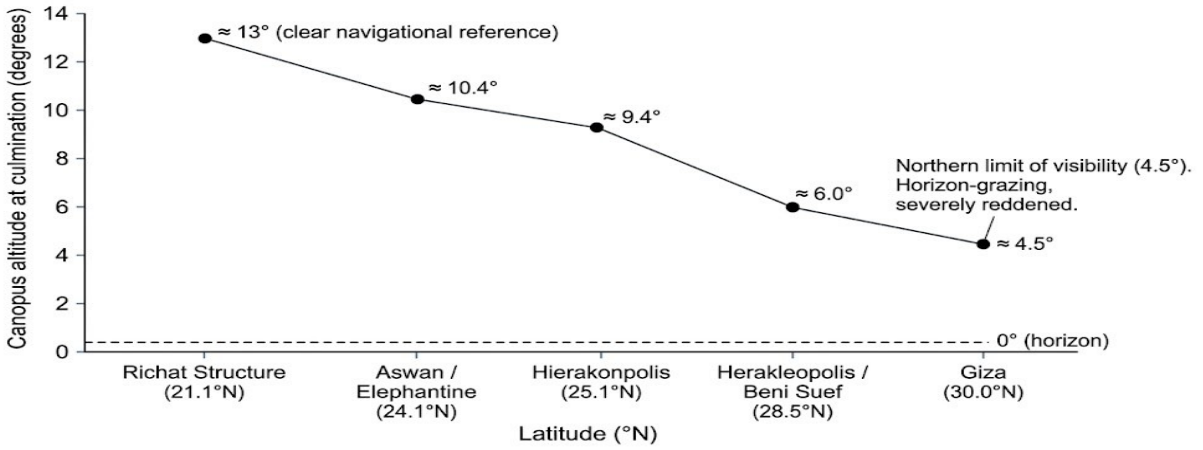
The script (zep_tepi_calculations.py, Part 1) self-tests against an independent astropy calculation and reproduces the figures quoted in this series. Two quantities should be kept distinct, since they are easily conflated: Canopus's declination at a given epoch, computed here, and the declination of the Canopus temple-orientation peak at −53.5° reported by Shaltout and Belmonte (2005: 283), which is a property of their survey of temple azimuths and not of the star at any date. The latter must not be substituted into an altitude calculation. One further point of direction: Canopus's declination becomes less negative through the periods this series covers, so its altitude at a fixed latitude rises with time. Earlier epochs give lower altitudes, not higher — the northward migration of the visibility limit recorded in Corridor I is the same fact seen from the other side. A simple geometric model shows what Canopus's low altitude implies, without establishing a construction prohibition. Take a pyramid height of 146.6 m, a half-base of 115.2 m and a starting elevation of 43 m.

A straight southward ray rising at 4.5° reaches the south face after 76.7 m of horizontal travel if started on the pyramid's central plane. Started at the King's Chamber midpoint (about 11 m south of centre, midway between Petrie's wall offsets, 1883, §55), the straight path is 66.5 m; started at the south wall (13.6 m south of centre), it is 64.0 m along the ray and 63.8 m horizontally. These are idealised comparisons, not surveyed shaft routes. The corresponding central-origin horizontal runs at 45° and 32.5° are approximately 45.6 m and 54.3 m; none of these figures is the length of an actual shaft. A Canopus-directed channel is therefore geometrically possible; its construction and its observational performance would need separate assessment. The surviving shaft inclinations (about 32.5° to 45°) do not establish a minimum viable angle, and atmospheric extinction at 4.5° imposes an observational penalty rather than making the star unusable. This paper proposes Canopus as an inherited southern reference whose low culmination at Giza may have influenced its monumental expression; no source records the builders' reasons for not providing a Canopus-directed shaft. The Wedjat is proposed, on this reading, as a portable complement: by observing the altitude of Canopus, an observer could estimate latitude along the same sky road.

A structural parallel to the Wedjat system itself emerges here. The six dedicated capacity fractions run from ½ to 1⁄64 hekat, but a quantity that did not fit them was reduced to terms of the series and of the ro, a hekat containing 320 ro, so that 1⁄64 hekat equals five ro (Peet 1923: 25). The parallel proposed here concerns the supplementation of a bounded sign series by another notational resource. It is not a limit of Egyptian arithmetic, and it is not a conclusion drawn from Ritter (2002). Within Corridor II's framework, in which the Wedjat encodes the Canopus visibility gradient, the parallel is close. No Canopus-family temple in the survey tables lies lower than 5.9° (Tanis, Mendes, Qsar al-Sagha), close to the 1/64 step (5.6°); Giza at 4.5° lies below it. At Giza — 30°N, pyramid-building era — Canopus culminates at approximately 4.5°. It is present above the horizon; it is not invisible. But, as set out

above, a Canopus-directed channel is geometrically possible; what the low altitude imposes is a heavy extinction penalty (apparent magnitude about 2.1 in clean air, about 3.2 in moderately dusty air), not an impossibility. The known shafts in the Great Pyramid range from about 32.5° to 45° (Badawy 1964; Trimble 1964).

No source records why the Great Pyramid has no Canopus-directed shaft. A shaft at about 4.5° is geometrically possible (Levy 2026h), so the absence is not explained here by a construction limit; this paper proposes only that Canopus's low culmination at Giza may have shaped how the star was expressed in the monument. A structural analogy is drawn with the Wedjat series: its six dedicated fractions end at 1⁄64 hekat, and smaller quantities remained expressible through supplementary notation (the ro). Reading the missing 1⁄64 as supplied by Thoth's externalised memory is this paper's interpretive analogy, not a metrological finding. The parallel between the end of the fraction series and the low altitude of Canopus at Giza is offered as an interpretive analogy (cf. Corridor II, Levy 2026b, Section 5), not as a physical or metrological limit. No prior peer-reviewed source has drawn this specific connection; it is presented as a synthesis within the framework of this series.



Canopus altitude at culmination decreasing from ~13° at Richat (21.1°N) to ~4.5° at Giza (30.0°N) in 5500 BCE. The Giza plateau lies at the northern limit of Canopus visibility. Data from precession-corrected coordinates (Paper II model).

Primary Purpose: Cosmological Encoding

A multi-generational migration of the kind documented in The Corridor Series does not merely displace a population geographically. It gradually erodes the fixed standards on which a cosmological system depends. Over centuries of movement, the cubit drifts as it passes through successive artisanal traditions without a master standard; the calendar loses its agricultural anchor as seasonal markers shift with latitude; Canopus — the navigational star that oriented the Saharan homeland — stands lower in the sky with each degree of latitude gained to the northeast, and steeply so on the last move north to the Memphite region; and the landscape that gave the Zep Tepi its relational grammar — the primordial mound, the concentric waters, the break in the ring — recedes first into living memory and eventually into mythologised legend. By the 4th Dynasty, the Green Sahara was a dry wasteland. The people who carried its cosmology no longer had a living landscape to point to as their zero point. They had institutional memory, the Shemsu Hor transmission chain, and the mathematical encoding of the Wedjat — but no fixed physical anchor. The pyramid is the solution to exactly this problem. Positioned at 30°N, oriented to Meskhetyu within about 4 arc minutes, aligned in its causeway toward the western origin, and engineered to outlast any other material made by human hands, the Great Pyramid is the zero point of the Zep Tepi cosmological system fixed in stone: an indestructible calibration standard permanently encoding every stellar reference, every cosmological relationship, and the memory of the landscape that gave rise to them — at a single location the desert could never take away.

The mythological dimension of this knowledge-preservation function is explicit in the Pyramid Texts. The Cannibal Hymn, inscribed on the antechamber east gable of the Unas pyramid (Utterances 273–274, c. 2375–2345 BCE), describes the king's apotheosis as the absorption of divine knowledge: *'Unas has swallowed the wisdom (sjA) of every god... Unas' span of life is Eternity, his limit is Everlastingness.'* The sjA — the divine faculty of perception and knowledge — is precisely what the king incorporates in his transformation. This is the ritual framework within which the pyramid's mathematical and astronomical encoding operates. The architecture that preserves knowledge externally in stone corresponds, in the Unas pyramid's inscription program, to the apotheosis of a king who has absorbed the sjA of every god internally. The two are not separate functions. The pyramid is simultaneously the external repository and the instrument of internal transformation — the place where encoded knowledge and the king's consciousness become the same thing.

On the reading proposed here, the Great Pyramid was built to permanently encode the Zep Tepi cosmological system in the most durable medium available. It is not *primarily* a tomb. It is a three-dimensional cosmological monument that recreates the primordial landscape from which Egyptian civilisation derived its sacred worldview.

This cosmological reading does not replace the funerary interpretation — it prioritizes it. The pyramid is the machine of royal transformation precisely because it is the Zep Tepi made stone. The king becomes divine by re-enacting the First Time. **A more precise formulation is that the pyramids' design is not optimized for burial** — the absence of canopic equipment, identifying inscriptions, and burial goods suggests that preservation of the body was not the primary architectural driver.

Independent Convergence: Giza as "Written Landscape"

The reading of Giza as a cosmological landscape is not isolated to the present hypothesis. The archaeoastronomer Giulio Magli, publishing in peer-reviewed venues including Cambridge University Press, has independently argued that "the Giza plateau can be interpreted as a 'written landscape' where the pyramids represent the hieroglyph for the primordial mound" (Magli 2011; cf. Magli 2013, 2016). Magli's analysis, grounded in the precise orientation data of the pyramids and their relationship to Heliopolis, converges on the same core insight that animates the Zep Tepi model: the Giza pyramids are not merely tombs but architectural encodings of the Benben, the primordial mound of Egyptian creation theology.

A second line of mainstream Egyptological convergence comes from material culture rather than archaeoastronomy. Lehner and Hawass (2017), in their definitive synthesis of the Giza evidence, document that the royal pyramids represent the culminating monumental expression of a long-term Egyptian funerary grammar — the mud-brick mound within an enclosure — that constitutes the basic funerary form across millennia and across all classes. Wong (2021) develops this point in the Cambridge Archaeological Journal, arguing that this form is the structural common denominator of Egyptian funerary architecture from the Predynastic pit grave through the royal mastabas to the Old Kingdom pyramid complexes. The form is the same: central elevated mass, surrounding enclosure, separation of sacred core from outer world. The scale changes; the grammar does not.

The empirical anchor for this tradition is found at Hierakonpolis. The temple at Nekhen, excavated by Quibell and Green (1902) and reinterpreted by McNamara (2008), stood on a sand mound encased in a stone revetment; since its discovery that revetted mound has been read as the foundation of an Early Dynastic temple (McNamara 2008). Beside it, the Predynastic ceremonial centre HK29A (Naqada IIAB to the First Dynasty; Friedman 2009) shows that monumental ritual architecture was already in use there. The revetted mound, a raised central form within a bounding wall, is the kind of structure (central elevated form within a ring boundary) that this paper proposes the Giza pyramids monumentalize at scale. This is at the same site as HK6, the predynastic cattle cult center documented in Corridor III, and the revetted mound predates the Step Pyramid by roughly three centuries on the conventional Early Dynastic dating. The Zep Tepi cosmogram is therefore not a

hypothetical construction reverse-engineered from Giza. It is a documented architectural form attested at the Shemsu Hor capital from the late Predynastic into the Early Dynastic period. The Giza pyramids are the monumental, state-scale instantiation of a structural grammar that had been expressed in stone and mudbrick across Egypt for several centuries before Khufu's reign.

The convergence between Magli's mainstream archaeoastronomical analysis and the Zep Tepi framework is not a matter of citation for authority. It is evidence that the cosmological reading of Giza is not a fringe interpretation but a model that satisfies a dense set of empirical constraints — constraints that are independently documented and peer-reviewed. The question is not whether Giza encodes cosmology. The question is which cosmology it encodes, and from where that cosmology originated. The Zep Tepi model proposes a specific answer: the cosmology of the Green Sahara, carried by pastoralist migrants, preserved by the Shemsu Hor, and instantiated in stone at Giza.

Three Registers of Architectural Purpose

• **Backward-looking (restoration):** This paper proposes the pyramid encodes what migration eroded — the relational grammar of the Richat landscape, the Canopus sky of the Saharan homeland, the mathematical standards of the Zep Tepi system. It does not recover these things. It permanently marks their memory in stone that cannot drift.

• **Translational (encoding):** The Richat Structure is circular — the natural, cosmic, divine form of the Zep Tepi mound. The Giza complex is square-based — the human architectural expression of the same relational system. The circle is not copied; it is translated. The pyramid complex encodes the relational grammar — central elevation, bounded space, transition water, directional axis — in the architectural language of human construction. The form changes; the cosmological relationship does not.

• **Forward-looking (insurance):** The pyramid was built not only for what was lost, but against what might come again. The African Humid Period collapse may have been the founding trauma the entire institutional memory was organised around. A civilisation that had lived through one world-ending environmental event had every reason to build beyond the reach of any future one. The pyramid does not merely preserve that memory. It guarantees it: an archive in the only medium that cannot be dissolved by sand, outlasted by drought, or erased by the next turning of the sky.

These three registers define the pyramid's complete function: a monument designed simultaneously as memorial, knowledge repository, and durable preservation against civilisational loss.

Secondary Purpose: Royal Transformation

The pyramid also served as the mechanism of royal apotheosis — the architectural machine through which the dead pharaoh underwent transformation from human king to divine being. This is the function described in the Pyramid Texts: the king ascending to the Imperishable Stars, merging with Ra, becoming Osiris. The two purposes — cosmological encoding and royal transformation — are not in conflict. They are the same purpose at different scales. This reading aligns with mainstream Egyptological scholarship: Assmann (2005) documents that Egyptian mortuary religion was centred on transformation rather than interment, the pyramid functioning as an instrument of royal becoming rather than a container for remains (Assmann, J. 2005. Death and Salvation in Ancient Egypt. Trans. David Lorton. Cornell University Press).

Mechanism of Transmission

How does a landscape become an architectural system? The proposed transmission does not require direct architectural copying of a landscape. It operates through cognitive and ritual encoding. Landscapes such as Richat are not reproduced visually but abstracted into cosmological principles ---

central emergence, bounded order, liminal water, and directional transformation. These principles are preserved through ritual practice, oral tradition, and symbolic systems (e.g., the Wedjat as a fractional and integrative schema), and later instantiated in architecture when conditions allow. The resulting structures therefore reflect not the physical form of the original landscape, but its encoded relational logic.

This material approach to cultural transmission has a relevant Egyptian comparison in Olabarria's study of Middle Kingdom Abydos. She argues that the inscriptions show stelae and chapels to have been regarded as "foci of memory created by, and for, performance and ongoing celebration" (Olabarria 2020, accepted manuscript: 23). Her analysis connects monuments, repeated interaction and the creation of commemorative space. This paper extends that approach to the proposed role of the pyramid as a durable carrier of an ancestral landscape's relational grammar: the pyramid as mnemonic monument, the causeway as a processional setting, and Giza as a place in which an inherited cosmological pattern could be re-enacted. The identification of that pattern with an ancestral Saharan landscape is the present hypothesis; it is not a historical identification made by Olabarria's Abydos study.

The performative dimension of this transmission is consistent with broader Egyptian material culture analysis, including Kroft's (2024) examination of decorated ware vessels as vehicles for memory expression in formalized ritual contexts.

The Egyptian comparison above sits within a wider comparative literature on how non-literate and partly-literate societies encode durable knowledge, which supplies the mechanism this hypothesis requires. In cognitive archaeology, Kelly (2015) documents that oral societies stored large bodies of pragmatic knowledge — including astronomy, calendars, and navigation — in monuments and landscape features functioning as mnemonic devices, reinterpreting Stonehenge, Chaco Canyon, and Poverty Point on that basis. In cultural astronomy, Hamacher (2018) demonstrates that oral cultures encoded precise astronomical observations, including stellar variability and periodicity, and transmitted them across generations for calendrical and ritual use. The cognitive constraints that make such transmission faithful rather than degradative — theme, imagery, and rhythmic structure operating together — are set out by Rubin (1995), while Vansina (1985) provides the methodological framework for treating the resulting traditions as recoverable information rather than invention.

Two points follow. First, the mechanism proposed here is not an ad hoc postulate but an instance of a documented cross-cultural phenomenon: monuments serving as knowledge stores, and oral tradition as a high-fidelity carrier. Second, the practice of encoding precise astronomical periods is independently attested within Egypt itself. Jetsu and Porceddu (2013, 2015) present statistical evidence that the Cairo Calendar (Papyrus Cairo 86637) records the 2.85-day period of the eclipsing binary Algol and the 29.6-day lunar period in its day-by-day structure — the earliest known documentary record of a variable star's period. That source is Ramesside and therefore far later than Khufu, and its Algol identification is debated; it is cited here only to establish that period-encoding was a real Egyptian practice, not a modern projection. The claim advanced is accordingly the narrower one: that the Great Pyramid may represent a monumental instance of a mnemonic practice for which the comparative and Egyptological records already provide precedent.

Full Synthesis

Comparative Analysis: The Full Relational System in Cross-Cultural Perspective

Individual elements of the relational system (central elevation, bounded space, water access, directional axis) occur in other sacred landscapes. The claim here is not that Giza is unique in each element, but that the full integration of all four elements in a single planned complex, with the specific theological encoding (Zep Tepi, Nun/Benben, western orientation), is not clearly documented elsewhere in the current comparative sample.

The following table tests the proposed four-element relational system against other monumental landscapes, including newly added cases to expand the comparative scope.

Site	Central Elevation	Bounded Space	Water at Transition	Axis (Water → Monument)	Full Integration
Richat	✅ Dome	✅ Rings	✅ Basin	✅ West gap	✅
Giza	✅ Pyramid	✅ Enclosure	✅ Canal	✅ Causeway	✅
Nabta Playa	❌ Flat	⚠️ Stone circle	❌ Seasonal	❌ None	❌
Mesopotamian Ziggurats	✅ Ziggurat	✅ Precinct	❌ None	⚠️ Processional (not water-linked)	❌
Stonehenge	❌ None	✅ Ditch	❌ None	⚠️ Solstice (not water-linked)	❌
Teotihuacan (Sugiyama et al. 2021)	✅ Pyramids	✅ Ciudadela enclosure	⚠️ Engineered rivers (position at the transition not established)	⚠️ Avenue of the Dead axis (link to water not established)	⚠️ Unresolved
Göbekli Tepe (c. 9500–8000 BCE)	⚠️ Enclosures on hilltop (natural elevation, not built mound)	✅ Yes (circular/oval enclosures with limestone T-shaped pillars)	❌ No (located on dry plateau; no water at boundary)	❌ None (no processional axis connecting water to monument)	❌
North African Megalithic Circles (e.g., Nabta Playa, Senegambian stone circles)	❌ None (flat or low elevation)	✅ Yes (stone circles, varying diameters)	⚠️ Seasonal (Nabta has playa, not basin-scale)	⚠️ Possible stellar alignments (Nabta), but no water-to-monument axis	❌
Saqqara (Djoser)	✅ Step Pyramid	✅ Enclosure	⚠️ Dry Moat (contested hydraulic reading, Landreau et al. 2024; treated as provisional)	✅ Processional	⚠️ Partial (strongest precursor)
Later Egyptian Temples	⚠️ Sanctuary (not elevated)	✅ Enclosure	✅ Nile access	✅ Processional	⚠️ Partial (missing central elevation)

Site	Central Elevation	Bounded Space	Water at Transition	Axis (Water → Monument)	Full Integration
Angkor Wat (c. 1113–1150 CE, Cambodia)	✅ Central tower (Meru axis)	✅ Concentric enclosures	✅ Surrounding moat	✅ Causeway from moat to temple	⚠️ Full integration — convergent case (3,600 years post-Giza; no transmission linkage)

Borderline case: Saqqara (Step Pyramid complex of Djoser, 3rd Dynasty). The Saqqara complex exhibits central elevation (Step Pyramid), delimited sacred space (enclosure wall), and a directional axis (the Heb-Sed court and processional elements). The question of water integration at Saqqara has been reopened, though not settled, by Landreau et al. (2024, PLOS ONE 19(8): e0306690), who conducted transdisciplinary analysis of the Saqqara watershed and found that the Gisr el-Mudir enclosure has the structural features of a check dam, with topographic reconstruction supporting the existence of an intermittent lake west of the Djoser complex connected to the Dry Moat. On that reading the Dry Moat would be more than a symbolic water-proxy; the interpretation is recent and contested, and is treated here as provisional (Lauer 1936; Jeffreys 2010; Landreau et al. 2024). On this basis, Saqqara satisfies three of the four relational elements: central elevation, bounded space, and water at the boundary. The fourth element — a directional axis explicitly connecting water to monument — is present processionally but not hydraulically integrated in the manner of the Giza causeway. Saqqara is therefore the strongest precursor form of the full system. The element distinguishing Giza from Saqqara is not the presence of water but its deliberate hydraulic integration with the monument axis.

The intermediate step between Djoser and Khufu — the reign of Sneferu — provides independent support for this developmental trajectory. Rather than treating the Bent and Red Pyramids as sequential experiments — the second generated by the failure of the first — Belmonte and Magli (2015: 174) argue that the two pyramids of Sneferu at Dahshur form a single project conceived as such from its inception. They call the complementarity of the two pyramids' names "a further hint of a common project" (Belmonte and Magli 2015: 184), and they propose that the Bent and Red Pyramids were symbolic manifestations of the White Crown and the Red Crown of the king (Belmonte and Magli 2015: 193). This reading would transform Sneferu's reign from a period of trial-and-error correction into a coherent architectural programme, and it anticipates a unified project at Giza, which the same authors propose as two pyramids, the Sphinx, and associated temples and causeways under the name Akhet Khufu, "the Horizon of Cheops" (Belmonte and Magli 2015: 195). The full Giza complex thus represents not the independent decisions of successive kings but the culmination of a multi-generational tradition of planned sacred landscapes — a tradition whose earliest monumental expression, this paper argues, is the Phase Zero provincial pyramid program.

Comparative cases:

Göbekli Tepe (c. 9500–8000 BCE, southeastern Turkey): Göbekli Tepe is included here as the most prominent potential counterexample to the claim of Giza's structural uniqueness, and its inclusion is intended to test --- not assert --- comparability. Often cited as the world's oldest known megalithic complex, Göbekli Tepe features multiple circular and oval enclosures formed by T-shaped limestone pillars bearing intricate animal reliefs (Schmidt 2006). (As established in Corridor II (Levy 2026b, Section 5), the Wedjat fractional geometry --- the division of the Eye of Horus into ½, ¼, ⅛, 1⁄16, 1⁄32, 1⁄64 --- distinguishes the Saharan/Nile tradition of symbolic abstraction from the purely circular enclosures of Göbekli Tepe. The present comparison focuses strictly on the four-element landscape grammar.) The site is situated on a natural hilltop rather than a built mound and exhibits clear bounded

sacred space. However, it lacks any evidence of water at the boundary --- the site is located on a dry plateau with no associated water feature --- and there is no processional axis linking water to a central elevation.

Recent analysis by Verhoeven (2024) further clarifies Göbekli Tepe's ritual function, emphasizing boundaries, art, and communal ceremonial practice rather than cosmological encoding of a specific origin landscape; Dietrich et al. (2012) read the same assemblages as evidence of cult and feasting in the emergence of Neolithic communities. The site's monumental enclosures divided ritual space from the profane world, but this bounded-space function operates independently of the integrated water-axis-elevation grammar attested at Giza. Göbekli Tepe thus demonstrates that bounded sacred space and monumental construction can arise without the full four-element relational system — strengthening, rather than weakening, the claim that this specific integration requires explanation wherever it appears. While Göbekli Tepe demonstrates that hunter-gatherer societies could construct monumental sacred space, it does not satisfy the full four-element relational system. Its inclusion in this comparison is therefore a negative result: the most cited candidate for early monumental cosmography lacks the integrated water-axis-elevation grammar attested at Giza.

North African Megalithic Traditions (e.g., Nabta Playa, Senegambian stone circles): Nabta Playa (c. 8300–3400 BCE) features stone circles and possible stellar alignments (Wendorf & Schild 1998; Malville et al. 2008), and seasonal playa water was present nearby, but the water was not integrated as a boundary feature with a processional axis. The Senegambian stone circles (c. 700–1500 CE, later but representative of regional megalithic traditions) consist of multiple stone circles marking burial sites, but lack central elevation, integrated water, or directional axis. These traditions show that bounded sacred space and astronomical awareness existed elsewhere in Africa, but the full relational system (central elevation + bounded space + transition water + water-to-monument axis) is absent.

Angkor Wat (c. 1113–1150 CE, Cambodia): This is the most important case for testing the uniqueness claim and is included here as an explicit convergent case. Its cosmological design is documented in peer-reviewed literature: Stencel, Gifford and Morón established that its measurements “are related to practical astronomy and religious symbolism” (Stencel, R., Gifford, F. & Morón, E. 1976. Astronomy and cosmology at Angkor Wat. Science 193(4250): 281–287. DOI: 10.1126/science.193.4250.281); Romain provides detailed archaeoastronomical analysis (Romain, W.F. 2022. Angkor Wat. Journal of Skyscape Archaeology 8(1): 4–35. DOI: 10.1558/jsa.19967); and Magli addresses its cosmological design in a dedicated peer-reviewed chapter (Magli, G. 2024. Cambodia and Java. In: Archaeoastronomy. Springer, pp. 263–274). Angkor Wat achieves full four-element integration: a central tower (Mount Meru axis), concentric enclosure galleries, a surrounding moat at the boundary, and a causeway connecting moat to temple along a cardinal axis. It satisfies all four elements. Several features, however, distinguish its relationship to the present hypothesis from Giza’s. First, it postdates Giza by approximately 3,600 years. Second, no transmission linkage between the Green Sahara cosmological tradition and 12th-century Khmer religious architecture is implied. Third, the Angkor system derives its cosmological grammar from Mount Meru theology in the Hindu–Buddhist tradition — an independent, well-documented cosmological framework. Angkor therefore represents convergent cultural evolution: two independent civilisations arrived at the same structural solution from distinct cosmological starting points. This convergence confirms that the four-element system is architecturally achievable and culturally plausible across independent traditions. It does not, however, explain why Giza instantiated it 3,600 years earlier. The parsimony argument for transmission over independent invention at Giza rests on the convergence of additional evidence domains (genetic, archaeozoological, textual) that are not present for Angkor. Convergent evolution at Angkor therefore strengthens, rather than weakens, the argument: if the system can arise independently, it requires explanation when it appears alongside a documented corridor, an ancient North African genetic record spanning that corridor, and textual memory of a western origin.

Sample limits: The sites selected represent major, well-documented ritual landscapes across multiple cultural regions, including Southwest Asia (Göbekli Tepe), Europe (Stonehenge), Mesopotamia,

Mesoamerica, Africa, and Southeast Asia (Angkor Wat). The sample is not exhaustive, and future research may identify additional parallels or counterexamples. The claim is therefore restricted to the current comparative sample.

Conclusion of comparative analysis: While individual elements of the proposed system occur widely, the only other site positively identified here as achieving full four-element integration is Angkor Wat (12th century CE, Cambodia) — 3,600 years after Giza and with an independent cosmological derivation from Hindu–Buddhist tradition. Teotihuacan, where the 2021 lidar study documents elevation, enclosure, an axis and engineered rivers, remains unresolved because the water–monument relation has not been tested here. Within the current sample, Giza remains the earliest known full instantiation of the system, and the only one for which a documented corridor, an ancient North African genetic record spanning that corridor, and textual memory of a western origin are available as supporting evidence. Göbekli Tepe, despite its antiquity and monumental scale, lacks water integration and a processional axis. North African megalithic traditions (including Nabta Playa) exhibit bounded space and some astronomical awareness but lack the integrated water-axis-elevation system. Later Egyptian temples preserve a reduced form (boundary + water + axis) but lack the dominant central elevation. This pattern is consistent with — but does not prove — an evolutionary trajectory from Nabta (precursor) through Giza (full instantiation) to later temples (reduced form). The uniqueness of Giza's full integration within this expanded sample strengthens the hypothesis that Giza represents a deliberate architectural encoding of the Zep Tepi relational system, rather than a coincidental convergence of common sacred elements.

A note on the comparative method: The absence of the full four-element system at Göbekli Tepe, Stonehenge, or other sites does not constitute positive evidence that Giza's system was transmitted from Richat. It serves only to eliminate the alternative explanation that such systems arise universally or randomly across cultures. The positive case for transmission rests on the convergence of independent lines — hydrology, genetics, archaeozoology, texts, and astronomy — not on the comparative table alone.

The Constraint Filter: What Must Any Model Explain?

Taken together, the empirical features documented in this paper constitute a constraint filter. Any viable interpretation of the Giza complex must account for the following features simultaneously. While some constraints may be partially interrelated, they originate from distinct domains — survey measurement, textual sources, landscape archaeology, and theological analysis — and therefore cannot be reduced to a single explanatory variable.

Constraint	Empirical Finding	Source
Causeway orientation about the east–west axis	Khafre 283.4°, Menkaure 269.2°, Khufu ~255°; opposed deviations about the east–west axis, mean 269.4°	Nell & Ruggles (2014)
Heliopolis alignment	Giza Diagonal (northeast–southwest layout line) reported by Lehner (1985b: 143, n. 24, citing Goedicke); a Heliopolis alignment is a proposal, approximate and debated	Lehner (1985b)
Institutional memory	North-west corners of Sahure, Neferirkare and Neferefre point to Heliopolis though it is not visible (alignment proposed; the link is treated as symbolic: Joyanes-Díaz et al. 2025)	Magli (2010); Joyanes-Díaz et al. (2025)

Constraint	Empirical Finding	Source
Integrated landscape planning	Khufu quarry aligns with pyramid; volume matches pyramid (2.76M vs. 2.59M m³)	Lehner (1985)
Material-theological convergence	King's Chamber granite from Elephantine; Khufu's name = "Khnum is my Protector"; Khnum = ram-headed god of Elephantine; Elephantine = "door of the south"	Shaw (2000); Britannica; Belmonte et al. (2016)
Cultural continuity	Egyptian conceptual landscapes show 2000-year symbolic continuity	Magli (2011)
Engineered water at boundary	Khufu Branch canal and Ahramat Branch; Khufu harbour basin at pyramid base	Sheisha et al. (2022); Ghoneim et al. (2024); Younes et al. (2024)
Bare interior walls	No hieroglyphics in 4th Dynasty pyramids; Pyramid Texts first attested in the pyramid of Unas (proposed explanation of this paper: embodied knowledge fading)	Allen (2005); physical survey

If these features reflected only random or purely functional design, the following null-model predictions would be expected. These rows test that random-or-functional null; they do not test transmission from the Green Sahara, and an Egyptian-only cosmological account is not excluded by them. The expectations in the left column are assumptions rather than established results: a functional account can itself predict a river-access, causeway and monument arrangement, so the arrangement alone does not reject it. The rows record what is found; whether it exceeds functional expectation is not shown here:

Proposed Functional Expectation	Empirical Finding	Status
Pyramid placement would be random or purely functional, without consistent water-axis-elevation integration	Giza exhibits integrated central elevation + bounded space + water at boundary + western axis	**Not discriminated by this comparison**
Causeway orientation would show no directional consistency (or would be fully explainable by local topography alone)	All three Giza causeways organised about the east–west axis, deviating in opposed senses (Khufu ~255°, Menkaure 269.2°, Khafre 283.4°; mean 269.4°)	**Not discriminated by this comparison**
No directional consistency in pyramid placement across dynasties	North-west corners of Sahure, Neferirkare and Neferefre point to Heliopolis though it is not visible (alignment proposed; the link is treated as symbolic: Joyanes-Díaz et al. 2025)	**Not discriminated by this comparison**
Water systems at pyramid sites would show no geometric integration with the monument axis (water placement would be purely functional — access from any convenient direction, with no alignment to a cardinal causeway or directional cosmological axis)	The harbour and associated Nile-channel access are linked to the pyramid approach by its causeway. The causeways are organised about the east–west axis, with opposed deviations rather than an exact due-west alignment (Sheisha et al. 2022; Younes et al. 2024; Nell & Ruggles 2014).	**Not discriminated by this comparison**

Proposed Functional Expectation	Empirical Finding	Status
No correspondence between four-element relational system and earlier Saharan or Predynastic ritual sites	Nabta Playa exhibits precursor form (bounded space + water proximity, lacking full integration)	**Not discriminated by this comparison**

The Zep Tepi model is consistent with all empirical constraints in this filter as currently defined. It accounts for the western orientation (toward the Saharan origin), the Heliopolis alignment (toward the Primeval Mound, the Benben), the institutional memory (the Shemsu Hor transmission chain), the integrated landscape planning (Giza as unified cosmological statement), the material-theological convergence (Khnum as Khufu's protector, Elephantine as granite source, Canopus as stellar counterpart), and the cultural continuity (2000-year persistence of symbolic grammar).

The following table summarises each major competing interpretive framework against eight criteria, two of which — Grand Gallery function and Subterranean Chamber — fall outside this paper's declared scope and are marked as such rather than claimed. The ratings are the author's qualitative judgements, not sourced scores, and no competing framework is rated ✓ on more than two criteria. Credit is given where each framework genuinely addresses a criterion; partial credit (~) indicates the criterion is addressed in limited scope, contested, or domain-restricted. The table is intended as a comparative research tool, not a dismissal of prior scholarship — several of the frameworks listed provide the archaeoastronomical and cosmological foundations on which this hypothesis builds.

Hypothesis	Empty chambers	Stellar shafts (system)	Grand Gallery function	Subterranean chamber	Landscape grammar	Dimensional encoding	Falsifiable predictions	Origin tradition
Royal funerary monument Mainstream Egyptology	~	~	~	~	~	~	—	✗
Labor-state ideology Lehner, Hawass	~	✗	~	✗	~	✗	—	✗
Solar / benben cosmology Stadelmann et al.	~	✗	✗	✗	✓	~	—	✗
Stellar soul-ascent Badawy, Trimble	~	✓	✗	✗	✗	✗	✓	✗
Orion correlation theory Bauval & Gilbert (1994)	✗	~	✗	✗	✓	✗	—	✗
Osirian funerary theology Standard religious interpretation	✗	~	✗	✓	~	✗	—	✗
Zep Tepi / Pyramid as Memory This hypothesis (Levy 2026)	~	~	—	—	~	~	✓	~

✓ Fully addressed | ~ Partially addressed or contested | ✗ Not addressed — The ratings are the author's qualitative judgements, not sourced scores. For this hypothesis, ~ marks claims that are proposals under test: the correspondences were identified post hoc and intent is not demonstrated. — Not rated: outside this paper's declared scope (the Grand Gallery and Subterranean Chamber are not addressed here and are not claimed) or, for "Falsifiable predictions", no basis in this paper for rating a rival framework. "Origin tradition" asks whether a framework addresses a transmission chain from the Shemsu Hor period; the rivals listed do

Hypothesis	Empty chambers	Stellar shafts (system)	Grand Gallery function	Subterranean chamber	Landscape grammar	Dimensional encoding	Falsifiable predictions	Origin tradition

not claim one.

Alternative models that treat Giza as a collection of independent royal tombs, or as purely functionally determined by topography and available materials, are rated ✓ on at most two of these criteria. That is a statement about the qualitative ratings above, not a test of those frameworks.

The question is not whether the Zep Tepi model is "proven." The question is whether any alternative model can be constructed that also passes through the constraint filter intact. The field is invited to propose such models. In the comparative table above, no alternative framework is rated ✓ on more than two of the six in-scope criteria; this paper's own row is rated ✓ on one and ~ on five, because its claims are proposals under test. The field is invited to propose and test such frameworks; the evaluation criteria are stated in the comparative table above.

The hypothesis does not claim the pyramids had no funerary role. The two readings — cosmological encoding and royal transformation — are complementary at different interpretive scales. Alternative explanations for individual features (robbery accounting for missing valuables, functional necessity explaining water channels, chronological lag explaining absent hieroglyphs) are addressed within the evidence chapters above. The claim is that the full constraint set — empty chambers, western axis, integrated water, stellar alignment, and institutional memory — is better explained by the cosmological reading than by any available combination of independent functional explanations. Convergent cultural evolution at Angkor Wat confirms the four-element relational system is independently achievable; it does not explain its earlier appearance at Giza alongside a documented corridor, an ancient North African genetic record spanning that corridor, and textual memory of a western origin.

Cross-Site Test of the Relational Triad

The relational reading advanced above makes a falsifiable prediction. If the Giza configuration encodes a cosmological template rather than a site-specific engineering solution, the same relational triad — water access at the sacred boundary, a directional axis, and an elevated central feature — should recur at other Old Kingdom ceremonial complexes, and should appear even where the site is not a royal tomb. The prediction is tested here against four further complexes spanning the Third to Fifth Dynasties, each scored on three independent criteria: (1) water access at the sacred boundary — a valley temple, harbour, or quay at a canal, lake, or Nile channel; (2) a directional axis — a causeway or processional spine linking that water access to the centre; and (3) an elevated central feature — a pyramid, benben platform, or sanctuary mound. Each criterion is recorded as present, symbolic or partial, or absent.

The triad is supported at the examined Dahshur and Abusir complexes and provisionally supported at Nyuserre's sun temple. At Dahshur, the complex of Sneferu — Khufu's father, one reign before Giza — pairs the Bent Pyramid with a valley temple, a lower causeway, and an associated harbour set within a deliberately managed water landscape, as documented by the German Archaeological Institute's excavations (Alexanian et al. 2010). At Abusir, the Fifth-Dynasty pyramids of Sahure and his successors place their valley temples directly on the shore of the Abusir lake, linked by causeways to the pyramids above (Verner 2001). In each case water access, axis, and elevated centre are all present.

The most diagnostic case is the one the prediction specifically anticipated: a non-funerary ritual site. The Fifth-Dynasty sun temples at Abu Ghurab are solar sanctuaries rather than royal tombs — the oldest cult buildings explicitly dedicated to Ra — yet they reproduce the identical triad. The valley

temple of Nyuserre's solar complex supplies the water access, a causeway supplies the axis, and in the position a pyramid would occupy stands an obelisk-type structure on a plinth (Janák, Vymazalová & Coppens 2011: 431–432); the valley temple was itself newly excavated by the Italian Archaeological Mission at Abu Ghurab, directed by Massimiliano Nuzzolo (University of Turin) and Rosanna Pirelli (University of Naples L'Orientale), across the 2024 and 2025 seasons. Ludwig Borchardt had identified the structure in 1901 but could not excavate it because of the water table; falling groundwater has since made the work possible. The mission reported uncovering more than half of the valley temple, a monument exceeding 1,000 square metres, together with a ramp believed to have connected the temple to the Nile or one of its branches (Egyptian Ministry of Tourism and Antiquities, announcement of 12 December 2025, as reported by Ahram Online, 12 December 2025; Ministero degli Affari Esteri e della Cooperazione Internazionale, the Italian Ministry of Foreign Affairs and International Cooperation, 2026). As with the Hawass announcement discussed above, these findings are reported from official statements rather than peer-reviewed publication, and the water-access element at Abu Ghurab is therefore recorded here as provisionally rather than definitively confirmed. The benben is the primordial mound itself. That the same water-to-axis-to-elevated-centre relation should govern a site with no burial, and should place the explicit primordial-mound symbol at its focus, is difficult to reduce to funerary function; it reads as cosmological configuration.

The earliest complex sharpens rather than weakens the pattern. Imhotep's Step Pyramid at Saqqara already assembles the cosmological core — an elevated primordial mound within a bounded sacred precinct, itself ringed by the great rock-cut Dry Moat — but in inward-turned form. The moat's primary documented function is a quarry (Welc et al. 2015), and any reading of it as a symbolic water-boundary — or, on the recent and still-contested hydraulic interpretation of Landreau et al. (2024), as genuine water infrastructure — must remain secondary and provisional; the complex's axis, likewise, is internal (entrance colonnade to Great Court to Heb-Sed court) rather than an external causeway to the river. What the Fourth Dynasty adds is therefore not the invention of the template but its externalisation: the inward-turned enclosure becomes an outward causeway to a real harbour, and the symbolic boundary becomes engineered water. A configuration that develops across dynasties, rather than appearing fully formed, is precisely the signature of transmitted and elaborated knowledge rather than a single functional solution.

One objection must be met directly. The valley-temple-causeway-monument arrangement is the canonical Old Kingdom pyramid-complex form, and for the pyramid complexes it admits a straightforward functional reading: a valley temple at the water for arrival and the transport of stone, a causeway for processional access. Two features of the present sample resist that reduction. First, the sun temples carry the triad without a tomb, with a benben rather than a burial at the centre. Second, the water is not merely proximate but engineered — the purpose-built harbours and regularised wadis at Dahshur and Giza represent deliberate configuration rather than convenient location. The relational triad is, on this evidence, best understood as a cosmological template that the Old Kingdom progressively externalised and monumentalised — most completely at Giza.

Falsifiable Predictions

Predictive Test

If the proposed framework is valid (rather than post hoc), then undiscovered or less-studied Old Kingdom sites should exhibit partial or full integration of these elements. Specifically, the framework predicts that any newly excavated ritual or ceremonial site from the 3rd–5th Dynasty with preserved architectural remains should show (a) water access at the boundary of a delimited sacred space, (b) a directional axis connecting that water access to (c) an elevated central feature (pyramid, mastaba, or sanctuary platform). The absence of this relational integration in a well-preserved, non-funerary ritual site from this period would weaken the hypothesis.

Methodological Note on Evidentiary Weighting

This hypothesis draws on multiple independent lines of evidence: hydrology, genetics, archaeozoology, textual analysis, archaeoastronomy, mathematical analysis, cultural memory theory, archaeometry, and comparative architecture. No single line is conclusive. The argument is cumulative: the convergence of these independent lines — none of which was designed to confirm the others — is what gives the hypothesis weight. This is the structure of a consilience of inductions (Whewell 1840), not a proof from any single domain. The reader is invited to evaluate the hypothesis on the basis of the full convergence.

Why 440 Cubits: Formula-Fitting and Its Alternative

The question of why the Great Pyramid was built to a base of 440 royal cubits has an extensive literature, and the approach taken here differs from it in method rather than in conclusion. That difference is worth stating explicitly, since it determines what either approach can establish.

The established portion of that literature concerns the seked rather than the base. Petrie (1883) observed that a base of 440 with a height of 280 places the ratio 22/7 in the structure, the semi-circuit being 22 × 40 cubits and the height 7 × 40; These π- and φ-proportions follow arithmetically from a seked of 5 ½ palms, which Rossi (2003: 215–216) documents for Khufu's pyramid. This explains the ratio of base to height. It does not explain the base itself: a seked of 5 ½ produces the same proportions at any scale, and Meidum and Unas were both built to it at quite different sizes.

A wider body of work outside the peer-reviewed literature addresses the base directly, and does so by a consistent method: an expression is sought which evaluates to 440. Proposals in circulation include derivations from the mean number of lunations in a year, from $\sqrt{3} \times \pi$ scaled by powers of ten, from convergents of $\sqrt{3}$ such as 433/250, and from terms of a golden-section series. Each yields a number close to 440, and several are arithmetically elegant.

The difficulty with this method is not that any particular derivation is wrong. It is that the method cannot fail. Given π, $\sqrt{2}$, $\sqrt{3}$, φ, the lunation count and free choice of scaling factor, an expression evaluating to within a fraction of a percent of any given three-digit integer can be constructed. A derivation of 440 is therefore not evidence that 440 was chosen, because the same procedure would have produced a derivation of 439 or 441 with equal facility had the pyramid been built to those dimensions. No such analysis reports what its formula yields for bases the Egyptians did not use, and without that comparison the result carries no discriminating information.

The approach taken here inverts the procedure. Rather than searching for an expression that outputs 440, the analysis holds the method fixed — the same six dimensions, the same operations, the same target list, the same tolerance — and varies the base across every whole cubit from 75 to 600, a range spanning the smallest to well beyond the largest Old Kingdom pyramid. The question asked is not whether a formula can be found for 440, but where in that range the correspondence performance actually falls, and whether the answer depends on the targets being the ones Egyptian sources document.

Measured by the denominator margin defined above, and holding the seked at 5½ throughout, the Great Pyramid's base lies within roughly the highest-scoring 5 per cent of the 526 candidate bases, counting tied bases, at every tolerance within the observational band derived earlier. By competition rank it is tenth at ±0.10% (17 bases tied), second at ±0.15% (3 tied), and first at both ±0.20% (bases 121, 242 and 440 tie at margin +5) and ±0.25% (8 tied). The ordinal positions of 22nd, 4th, 3rd and 7th that a stable ascending-base listing gives are display order, not performance order. Outside the band, at ±0.30%, its competition rank is 23rd (40 bases tied).

The control is the part that distinguishes this from the formula-fitting tradition. The entire sweep was repeated against three hundred shadow target lists, each constructed by replacing every real target with a random value drawn from the plausible range of its own physical category, so that a lunar period remains lunar-scale and a planetary synodic remains planetary-scale. If 440 were simply an

arithmetically fertile number, it would continue to rank highly. It does not: against shadow targets its median position is about 275 of 526 under ascending-base tie-breaking (the saved diagnostics give 274.5) — the middle of the distribution — and it did not attain the maximum in any of the three hundred trials (0 of 300; the observed-inclusive count 1/301 ≈ 0.0033 is conditional on this shadow-list null and is not a probability upper bound). The standing of 440 is therefore a property of its relationship to the specific values Egyptian sources record as astronomically significant, not a property of the number itself.

What this establishes is bounded and should not be overstated. It does not demonstrate that the base was selected for this reason; a dimension chosen on other grounds may occupy an optimum without having been placed there deliberately, and no arithmetical test can distinguish the two cases. What it does establish is that the standing of 440 is specific to the Egyptian target set and survives a control that the formula-fitting approach does not attempt. The claim advanced is accordingly that the base stands among the highest-performing values for the documented targets — tied for the highest margin of 526 at the registered tolerance (with bases 121 and 242) and within roughly the highest-scoring 5 per cent across the band — and that this is unlikely to be coincidental — not that intent has been demonstrated.

The Denominator Margin Across Nine Pyramids

The denominator sweep reported above establishes that sixty-fourths outperform their neighbouring grids at the Great Pyramid. It does not by itself establish that this is a property of the Great Pyramid rather than of the fraction system. If k/64 outperformed k/48, k/60 and k/72 at every monument, the result would reflect an arithmetic peculiarity of the number 64 and would carry no architectural information. The sweep was therefore repeated across the nine documented Old Kingdom pyramids scored in the comparative analysis above.

Define the denominator margin as the correspondence count under k/64 minus the highest count achieved by k/48, k/60 or k/72 at the same monument, with dimensions, targets, operations and tolerance held constant. A positive margin means sixty-fourths outperform their immediate neighbours at that pyramid; a negative margin means they do not. The Great Pyramid returns a margin of +5, scoring 10 against a best neighbouring value of 5. Of the remaining eight pyramids, four return a margin of zero or below — Khafre at zero, the Bent Pyramid and Teti at −2, Sahure at −3 — and the four positive margins are small: +3 at Menkaure, +2 at the Red Pyramid, and +1 at Meidum and Unas. No other monument in the sample approaches the Great Pyramid’s margin.

The result was then tested against chance. Twenty thousand pyramids were generated with base and seked drawn uniformly from the Old Kingdom ranges, and the denominator margin computed for each. The mean margin across random dimensions is −1.32: for an arbitrary pyramid, sixty-fourths typically underperform their neighbouring grids rather than outperform them. A margin of +5 or greater occurred in 100 of 20,000 cases, giving p = 0.00500.

Unlike the raw correspondence count, this result is stable across most of the tolerance band. At ±0.10% the Great Pyramid’s margin is +3 (p = 0.043); at ±0.15%, +5 (p = 0.005); at ±0.20%, +5 (p = 0.005); at ±0.25%, +4 (p = 0.0185). At ±0.30% the margin falls to +2 and significance is lost (p = 0.116). The random mean remains negative at every tolerance tested. The result therefore holds across four of the five thresholds examined and fails at the widest, and that failure is reported rather than omitted.

The interpretation is narrow and should be stated as such. The test does not show that the Great Pyramid encodes astronomical values; it shows that whatever produces its correspondence count is specific to its dimensions and not to the number 64. Sixty-fourths do little or nothing at Khafre, at Meidum, or at Unas, with margins of 0, +1 and +1 — and Unas shares the Great Pyramid’s seked exactly. Scale, not the fraction system alone, carries the result.

Dependence on Individual Targets

A correspondence count of ten from fourteen invites the objection that a single fortunate target is carrying the result, with the remaining nine contributing nothing beyond ordinary arithmetic. This is testable directly. Each of the fourteen registered targets was removed in turn and the second Monte Carlo test re-run on the remaining thirteen, at the full N = 100,000 and with the same seed. Were one target responsible, its deletion would collapse the significance.

Thirteen of the fourteen deletions leave the result significant at $p < 0.05$. The single exception is the removal of the anomalistic month, at $p = 0.064$; the other thirteen deletions fall between $p = 0.00876$ and $p = 0.04769$. Had one correspondence been load-bearing, its removal would stand out as an isolated failure. The anomalistic month is the one deletion that moves the result across the 0.05 line, and a numerical excess remains (9 of 13 against a null mean of 5.58); no other deletion does, so the result is distributed across the set rather than resting on any other member of it.

One feature of the table deserves comment, because it bears on the composition of the target list. The four deletions that most improve the p-value are the four documented misses: removing Mercury gives $p = 0.00876$, the Sothic cycle $p = 0.00933$, the synodic month $p = 0.01647$ and the sidereal month $p = 0.01689$, all better than the baseline of $p = 0.02419$. Deleting a missed target leaves the observed hit count unchanged (10 of 13 instead of 10 of 14) but lowers the null's expected count, so the comparison improves. All four are retained. A list from which failures had been pruned would report a stronger figure and mean considerably less, and retaining these failures makes the reported list more transparent, without establishing that its original selection was unbiased.

The scope of this test should be stated precisely. It establishes robustness to the removal of targets; it says nothing about the addition of targets that were never included. That second question — whether values the Egyptians tracked have been omitted because they would have missed — is not answerable by any test conducted on the present list, and is addressed instead by the differential prediction stated under H_1, which specifies in advance where correspondences should and should not be expected to appear.

Derivation of the Matching Tolerance

The ±0.2% threshold used throughout requires justification, since a tolerance chosen for convenience would render any correspondence count meaningless. It is not chosen arbitrarily. It approximates the precision at which the target values were themselves knowable to the builders.

A synodic period is determined observationally by timing a recurring event — a heliacal rising, a first stationary point — and dividing the elapsed interval by the number of completed cycles. The achievable precision is therefore the timing error divided by the total span observed. Naked-eye determination of a heliacal event carries an uncertainty of roughly three to five days, since the date on which a star or planet first becomes visible depends on atmospheric extinction, horizon conditions and the acuity of the observer. Taking a conservative ±3 days and a record spanning three to five completed cycles — a realistic span for a single scribal working life — the resulting uncertainties are approximately 0.17% to 0.10% for Venus, 0.13% to 0.08% for Mars, 0.25% to 0.15% for Jupiter, and 0.26% to 0.16% for Saturn. The lunar periods, being short, carry proportionally larger uncertainty per cycle and require correspondingly longer records to reach comparable precision.

The 0.2% threshold sits within that band. It is not the precision of the monument, which is considerably finer: Petrie's four measured base sides, as tabulated in Dash (2012), range from 230.320 to 230.365 m, a spread of 4.5 cm (about 0.02%); this is a spread between sides, not a survey-precision estimate, but it indicates masonry accuracy roughly an order of magnitude finer than the threshold. The binding constraint on any encoding is therefore not the accuracy of the masonry but the accuracy of the astronomy the masonry would record. A threshold of 0.05% would demand that the encoding be more precise than the observations available to produce it; a threshold of 0.5% would admit values the builders could have distinguished. The registered tolerance is the one commensurate with the data.

This derivation was not used to select the threshold, which was fixed before the controls reported below were run and is fixed in the analysis protocol. It is offered as the reason the threshold is defensible rather than convenient, and it is stated here so that a reader who disagrees with the reasoning can locate the disagreement precisely. The tolerance sweep reported below shows the consequences of varying it in either direction.

Monte Carlo Statistical Analysis

Two primary Monte Carlo tests were conducted on the mathematical encoding section (N = 100,000 each, seed 42, precision threshold ±0.2%), supported by the further controls reported below and set out in the analysis protocol (§3.6): a target-value null, a matched-cardinality fraction null, a size-matched pyramid null, an evenly-spaced fraction null, a deterministic denominator sweep, and the independent-core and maximally-independent-core analyses. The analysis uses simple Wedjat operations only — dimension × fraction or dimension ÷ fraction — the exact computational form documented in the Rhind Mathematical Papyrus (Problems 56–58). Cross-dimensional addition and subtraction operations are documented in the Declared Methodological Constraints section and produce additional correspondences; they were excluded from the Monte Carlo analysis specifically to avoid inflating the expression space and to anchor the statistical test to the most directly defensible operation type. Restricting the expression class limits both observed matches and null opportunities; the reported p-values apply only to that declared class.

The same rules apply to every pyramid and every random comparison. The complete code and raw output — the single analysis script giza_analysis.py (Python 3 standard library only; random seed 42 reset before every stochastic block) and its output giza_analysis_results.txt, in the versions the analysis protocol specifies (§3.8) — are published alongside this paper for independent replication; corrections are welcome. The suite has been executed on independent hardware and, separately, in two browser-based Python 3.12 environments with no local filesystem and no shared state, reproducing every reported figure identically in each case. This establishes that the results depend on the deposited code alone and can be regenerated by any reader with a browser. It does not constitute independent verification of the analysis itself, which requires a reader who did not write it; determinism and correctness are separate properties, and only the first is demonstrated here. One block of the suite, the shadow-target control, is computationally heavy and may exceed the execution limit of some browser runners; it completes without difficulty in a standard local Python 3 environment.

Test 1 (Wedjat system specificity): The Wedjat binary fraction system applied to the Great Pyramid's six exterior dimensions achieves 10 of 14 astronomical target correspondences. Against 100,000 random fraction systems of equivalent structure applied to the same dimensions, the random mean is 6.26 (±1.65 SD). Giza's result is 2.27 standard deviations above the random mean (empirical $p = 0.01497$, $p < 0.05$). Only 1,497 of the 100,000 random fraction systems scored 10 or higher.

Test 2 (Giza dimensional specificity): With Wedjat fractions held constant, the Great Pyramid's dimensions are compared against 100,000 randomly generated Old Kingdom-style pyramids with base varied uniformly from 75–440 rc and seked from 4.0–7.5 palms/cubit (Rossi 2003). The random mean is 5.76 (±1.93 SD). Giza's result is 2.19 standard deviations above the random mean (empirical $p = 0.02419$, $p < 0.05$). Only 2,419 of the 100,000 randomly generated pyramids scored 10 or higher. Both results remain statistically significant after Bonferroni correction for two simultaneous tests (adjusted threshold $p < 0.025$): Test 1 $p = 0.01497$, Test 2 $p = 0.02419$.

System Specificity: The Primary Test

The analysis protocol designates a single primary decision rule (§3.7), and it is not the correspondence count. At equal cardinality — each rival historical fraction system downsampled at random to the Wedjat set's exact size of sixty-three values — the Wedjat system must out-reach every rival across the tolerance band from ±0.10% to ±0.30%. That rule was chosen because it is the one test in the suite that succeeds across the five tested thresholds for the eleven-target set, and because

it isolates the question the correspondence count cannot answer: whether the specific dyadic subset, rather than the size of the toolkit or the general reachability of the targets, is doing the work.

The result is reported here in full. In the raw head-to-head at the registered tolerance, the Wedjat set reaches 10 of 14 targets with 63 fractions; Egyptian unit fractions reach 11 with 1,923, Babylonian sexagesimal 4 with 118, small-denominator simple ratios 4 with 45, and decimal 8 with 99. Expressed per hundred fractions the Wedjat rate is 15.87, against 0.57, 3.39, 8.89 and 8.08 respectively. Downsampled to sixty-three values (N = 20,000 random subsets per system), no rival reaches the Wedjat score: not one subset in twenty thousand attains 10 of 14 for Egyptian unit fractions, Babylonian sexagesimal or decimal, and on the independent eleven-target set the highest rival probability of reaching the Wedjat score of 8 of 11 is 0.0001 (as printed to four decimal places, not an exact upper bound). The simple-ratio system contains fewer than sixty-three fractions and cannot be downsampled to equal size; it is therefore excluded from the equal-cardinality test and from the decision rule, as the protocol states.

Repeating the test at each tolerance across the registered band gives the profile the decision rule requires. On the independent eleven-target set, at ±0.10% the Wedjat set reaches 5 of 11 and the highest rival probability is 0.0032; at ±0.15%, 6 of 11 and 0.0016; at ±0.20%, ±0.25% and ±0.30%, 8 of 11 with highest rival probabilities of 0.0001, 0.0004 and 0.0018. The maximum across the entire band is 0.0032. The primary criterion is therefore met, and — unlike the correspondence count, whose significance moves with the tolerance — this result holds at every threshold when the tolerance is tightened or loosened. It is the finding on which the dimensional argument rests.

Its scope should be stated as precisely as the result. The dyadic set outperforms equal-sized uniformly sampled subsets of the three explicitly constructed comparator pools under this target list and scoring rule. The pools are finite constructions, not complete historical systems: the Egyptian pool is the single unit fractions 1/2 to 1/64 plus their proper pairwise sums; the Babylonian pool is k/60 and k/3600 for k = 1 to 59; the decimal pool is k/10 for k = 1 to 9 and k/100 for k = 1 to 99. It does not establish that the correspondences were deliberately placed, and it does not exhaust the space of possible rival systems: a culturally attested system not tested here could in principle perform comparably, and identifying one would weaken the claim.

Exact counts for the historical pools. Because each pool is finite and the sixty-three values are drawn uniformly without replacement, the tails above can also be counted exactly rather than sampled, under the same pools, hit rule and tolerances. On the independent eleven-target set the exact Egyptian-pool tails are 0.00276 at ±0.10%, 0.00162 at ±0.15%, 0.0000681 at ±0.20%, 0.000229 at ±0.25% and 0.00159 at ±0.30%; the Babylonian and decimal pools cannot attain the observed score, so their tails are exactly zero. The maximum over the band is 0.00276, consistent with the sampled 0.0032. After deduplicating the Egyptian pool by exact rational value (1,923 entries become 1,914), the baseline tail is 0.0000703 and the band maximum 0.00282. The full fourteen-target count does not pass every such comparison (the decimal pool at ±0.10% has an exact tail of 0.405), which is why the primary rule is stated on the independent set. These values come from supplementary counting calculations, not from giza_analysis.py, and that code is not part of the files deposited with this version.

Sensitivity to comparator construction. The historical-pool result does not extend unchanged to every mathematical comparator family. At ±0.2%, conditioning the original six-generator random family on all subset sums being proper fractions gives empirical upper tails of 0.0172, 0.0110 and 0.0535 for the full fourteen-, independent eleven- and nine-target sets (100,000 systems, seed 42). Conditioning additionally on the exact observed endpoints (smallest fraction 1/64, total 63/64), under a uniform-simplex conditional law, gives 0.0614, 0.0538 and 0.2202. Fixing the smallest fraction at 1/64 grants every such comparator the anomalistic-month match through 1760 × 1/64 = 27.5, so this tests the pattern that remains once that feature is shared. Exact counting of uniformly chosen 63-value subsets of the 127 values k/128 gives tails of 0.1293, 0.2331 and 0.3951; this finer grid is a modern comparator, not an attested seventh Horus-eye sign. These results bound broader claims of numerical

uniqueness without replacing the historically defined pool comparison. They answer different conditional questions, and their probabilities must not be combined.

Neither result constitutes proof of deliberate cosmological encoding. Together they establish that the observed 10-of-14 target pattern is statistically non-random under two independent null models: unlikely to arise from an arbitrary fraction system on these dimensions, and unlikely to arise from the Wedjat system on arbitrary Old Kingdom pyramid proportions. These two tests establish that the correspondence count is improbable. They do not establish what produces it, and on their own they remain vulnerable to the objection that some feature of the fraction system, rather than of the monument, is doing the work. The three analyses that follow — the evenly-spaced fraction null, the denominator margin across nine pyramids, and the base sweep with its shadow-target control — address that objection directly by varying one element at a time while holding the rest fixed. They are reported after the primary tests because they are specificity analyses, several of which also report model-conditional tail probabilities, and because two of the three are post-hoc, as declared in the analysis protocol. In the assessment offered here they carry more evidential weight than the raw count, since each was constructed so that it could have failed. The analysis also examines a nine-pyramid Old Kingdom comparison sample. When the identical test is applied to nine documented pyramids using their published base and height figures — design values where these are securely reconstructed, as set out in the Declared Methodological Constraints — Giza leads all three architectural periods:

5th–6th Dynasty (post-Giza): Teti 5/14, Unas 7/14, Sahure 5/14. Giza Complex (Khufu to Menkaure, c. 2580–2477 BCE on the long-reign chronology of Phase Zero, Levy 2026d): Khufu 10/14, Khafre 7/14, Menkaure 8/14. Sneferu's Programme (pre-Giza, c. 2613–2580 BCE on the same chronology): Red Pyramid 8/14, Bent Pyramid 8/14, Meidum 7/14. The decline in correspondence density after Giza is consistent with the attenuation model proposed throughout this series: institutional capacity to transmit and apply the full cosmological encoding tradition weakened after the 4th Dynasty peak. Whether the builders of later pyramids lacked the knowledge, the resources, or the intention is a question the data cannot resolve. That Giza scores highest within this nine-pyramid sample is what the comparison shows; whether that reflects the maximum expression of the tradition is an interpretation.

Domain Specificity: The Stellar Negative Control

The controls above hold the monument fixed and vary the fraction system, the dimensions, the target values or the tolerance. A further control varies the target domain itself, and it addresses the objection that most directly threatens the result: if the Great Pyramid's six dimensions reach whatever they are pointed at, a score of ten of fourteen against the registered targets establishes nothing about those targets. The test asks whether the same monument, under identical rules, also reaches stellar positions.

Eleven stars are carried: Thuban, Sirius, Canopus, Arcturus, Alnitak, Alnilam, Kochab, Mizar, Alkaid, Dubhe and Alpha Centauri. Both Dubhe and Arcturus are retained because the northern Nabta Playa alignments have been revised between them (Malville et al. 2008). ICRS J2000 positions with proper motion are precessed to the construction epoch under the Vondrák et al. (2011) long-term model, then converted to three angular quantities as seen from Giza at 29.9792°N: declination, entered as angular distance from the celestial equator so that northern and southern stars share one range; rising azimuth, where the star crosses the horizon at all; and altitude at upper culmination. Five of the eleven are circumpolar at this epoch and therefore have no rising azimuth. With the obliquity of the ecliptic, Giza's latitude and the circumpolar limit added, the set comes to thirty-one angular targets. Those targets are then scored against the same six dimensions, the same sixty-three Wedjat fractions, the same two operations and the same ±0.2% tolerance used throughout, and each target is replaced by a random value drawn from its own category range — a declination stays a declination, an azimuth an azimuth — and the monument re-scored 200,000 times at seed 42.

The pyramid reaches five of thirty-one stellar targets, 16.1%, against a chance expectation of 4.83 of thirty-one, 15.6%, at p = 0.5431. The stellar domain is statistically indistinguishable from chance. The five that do reach tolerance are not obscure: Alnitak's culmination altitude via half-base × 13/64 at 0.060%, Mizar's declination via height × 18/64 at 0.138%, Canopus's rising azimuth via height × 37/64 at 0.157%, Sirius's culmination altitude via apothem × 7/64 at 0.163%, and Canopus's declination via apothem × 10/64 at 0.198%. Sirius, Canopus and Alnitak of Orion's Belt are the three most significant stars in the tradition, and the total is still what chance predicts.

Because the construction year is not known, the control is re-scored at every year of the long-reign window from 2580 to 2540 BCE against the same chance distribution. The count ranges from three to six hits, with a mean of 5.05 against the chance expectation of 4.83, and P(≥ observed) ranges from 0.35 to 0.88. The control is never significant at any year in the window. One sensitivity should be recorded: the epoch quoted above is Julian year −2560, and at Julian year −2559 — exactly 2560 BCE — Canopus's declination error against apothem × 10/64 moves from 0.198% to 0.202%, just outside tolerance, returning four of thirty-one at p = 0.736. Either figure leaves the stellar domain indistinguishable from chance; the one-year shift is a property of a hit sitting on the tolerance edge, not of the method.

The comparison is the point. Scored by the identical procedure, the registered fourteen-target suite returns ten of fourteen against a chance expectation of 6.25 at p = 0.023, while the stellar suite returns five of thirty-one against 4.83 at p = 0.543. Same monument, same six dimensions, same fraction system, same operations, same tolerance. The difference lies in the target set, not in any general flexibility of the pyramid's arithmetic. The code and its output are published alongside this paper as Part 4 of zep_tepi_calculations.py (formerly the standalone stellar_control.py) and stellar_control_output.txt.

Conditions Under Which This Hypothesis Weakens

In addition to the specific testable predictions above, the hypothesis weakens materially under the following conditions, each of which is in principle falsifiable by ongoing or future research:

Genomic convergence fails: If systematic analysis of additional Predynastic and early Dynastic genomes finds no contribution from the documented Saharan corridor population, the biological transmission chain is severed. This would weaken the biological component, not by itself falsify transmission by cultural diffusion, which the genetic record cited above treats as practice and knowledge moving without large-scale replacement.

Paleohydrological corridor impassable: If refined modelling demonstrates the Highland Corridor was not traversable during the relevant period (c. 5,300–3,200 BCE), the proposed migration pathway is broken.

Second formation satisfies all criteria: If any Saharan formation is identified that simultaneously satisfies all four criteria applied across Corridor I and II — sufficient scale, documented Holocene water at the structure, documented human presence at the structure, and a central elevation rising from that water — the Richat identification loses its uniqueness as the only candidate.

Null model parity demonstrated: If formal Monte Carlo testing shows that the dimensional correspondences documented in the mathematical encoding section appear at comparable frequency across randomly generated geometric sets or comparable Old Kingdom monuments, the selectivity of the Giza pattern is not established.

Material culture discontinuity confirmed: If systematic analysis of assemblages from the proposed corridor nodes (Tassili, Takarkori, Nabta Playa, Hierakonpolis) reveals no shared material vocabulary across the migration period, the cultural transmission chain is weakened.

Shaft orientations structurally determined: If revised archaeoastronomical analysis demonstrates that the stellar shaft orientations are primarily structurally or topographically constrained rather than astronomically targeted, the cosmological intentionality of the shaft programme is not established by orientation data alone.

A note on the independence of evidence domains: Reviewers may argue that the domains are not truly independent — all are interpreted through the same framework. This is acknowledged. The independence claimed is disciplinary: the hydrology papers do not cite the genetics papers; the archaeozoology findings were not designed to confirm architectural hypotheses. Their convergence is therefore meaningful but not definitive.

A final limitation on the Richat identification: The identification of Richat as the origin landscape rests on the absence of any other known formation that satisfies all four criteria applied across Corridor I and II. This makes Richat the leading testable candidate, not a proven origin. The hypothesis does not require that Richat was the actual landscape encoded — only that the Zep Tepi relational system originated in a landscape with these features, for which the Richat is the only currently known candidate. Future high-resolution survey and targeted excavation in annular depressions elsewhere in the Sahara could identify additional candidates or falsify this distinction.

Scope, Boundaries, and Limitations

The Zep Tepi Series is structured so that each paper addresses a defined evidentiary scope. Defining the scope of the present paper explicitly, and what lies outside it, is an act of methodological discipline rather than defensive qualification.

What this paper claims: that the exterior architecture of the Giza complex instantiates a specific four-element relational cosmological system (central elevation, bounded sacred space, transition water, processional axis) whose origin this series locates in the Saharan pastoral tradition documented in The Corridor Series; that the exterior dimensions of the Great Pyramid contain mathematical and astronomical correspondences consistent with systematic knowledge preservation through the Wedjat fraction system; and that the compound evidence across cosmological, hydrological, archaeoastronomical, genetic, and mathematical domains makes deliberate encoding the more parsimonious explanation for the complex's design.

What this paper explicitly does not claim: proof of intentional encoding; certainty about transmission routes or timelines; that the mathematical correspondences are unique to Giza (the comparative analysis reported here covers nine documented Old Kingdom pyramids and twenty thousand randomly dimensioned ones; extension to non-Egyptian monuments remains future work); that the Shemsu Hor hypothesis accounts for all features of Giza's design; or that the cosmological reading of the complex excludes practical and logistical explanations. The paper repeatedly distinguishes "consistent with" from "proves" throughout.

Scope limits: this paper addresses the exterior of the Great Pyramid and the Giza complex in its landscape setting. No quantitative interior-encoding analysis, acoustic or electromagnetic-resonance analysis, or detailed Grand Gallery interpretation is undertaken here; selected interior observations (the King's Chamber shafts and the sarcophagus) are used as contextual evidence, and the proposed interpretation of the chamber arrangement remains preliminary. The Wedjat fraction system is treated here only as the arithmetic key to the dimensional correspondences documented above; its wider role as a knowledge architecture spanning medicine, architecture, calendrics, and theology is beyond the scope of this paper, though the medical and botanical strand of that architecture is treated in Levy (2026f).

The interval requiring explanation is the roughly 500-year span between the close of the Hierakonpolis tradition (c. 3,100 BCE) and the construction of the Great Pyramid (c. 2,580–2,540 BCE). That interval is not left as an inferential gap in this series. It is the subject of the Bridging Paper, Phase Zero: The Bull in the Sky (Levy 2026d), which documents a transmission chain running through it: the coordinated Minor Step Pyramid programme at seven provincial cult centres, the Djoser complex at Saqqara, and the archaeozoological evidence for Shemsu Hor continuity at Hierakonpolis. On that evidence the pyramid form, the stellar orientation procedure and the institutional apparatus for co-ordinated sacred construction were all already in place before Khufu, at provincial scale, encoding the

same Meskhetyu tradition. The present paper assumes those findings rather than re-arguing them. What remains genuinely open is narrower, and should be stated as such: the transmission chain is documented at the level of architectural programme, orientation practice and faunal continuity, but no single line of evidence traces a specific body of cosmological knowledge from Hierakonpolis to Giza in unbroken sequence. The claim advanced here is that the convergence of independent domains across the interval makes continued transmission the most parsimonious available explanation, not that any one line establishes it on its own.

What Remains Unknown

- Whether Khufu's body is elsewhere, and what became of it, cannot be determined from current evidence. Herodotus's description of a subterranean island tomb below the Giza Plateau — featuring a moat surrounding a central mound — corresponds architecturally to the Third Level of the Osiris Shaft (the New Kingdom name pr wsir nb rstaw is recorded by Hawass 2007: 391; on the Shetayet of Rosetau, Edwards 1986), the same structure whose Nun cosmological grammar this paper documents. The Third Level sarcophagus is officially characterised as a symbolic burial. This hypothesis notes the architectural correspondence as a convergence point without asserting proof of identification. Hawass has publicly stated his belief that Khufu's real burial chamber remains hidden inside the pyramid (Piers Morgan Uncensored, 15 May 2026), a view that does not itself dispute a funerary interpretation. This is additionally supported by the peer-reviewed scanning programme: four independent geophysical methods, across three peer-reviewed publications, have identified previously unknown interior spaces in the Great Pyramid (Morishima et al. 2017; Procureur et al. 2023; Schumacher et al. 2025), and a sealed corridor announced by Hawass in November 2025 (Egypt Independent, 9 November 2025) remains awaiting peer-reviewed publication.
- Whether the Big Void is a construction ramp, stress-relief chamber, or something else is not yet established.
- Whether the architects consciously intended every cosmological element cannot be determined without textual evidence the 4th Dynasty did not leave.
- Whether the Giza workers' cemetery contains individuals with North African / Saharan ancestry remains to be determined. No aDNA has been published from Heit el-Ghurab at the time of writing. At the time of writing, no ancient DNA has been published from any non-elite Old Kingdom cemetery in Egypt. The prediction therefore remains untestable pending future work, but the skeletal collections exist and the methodology is established.
- The Hawass 30-metre corridor (announced November 2025) remains unopened and unpublished in peer-reviewed form at the time of writing. Pending peer-reviewed publication, no definitive interpretation is possible.

Testing Protocol

The 'Pyramid as Memory' hypothesis generates several clear, falsifiable predictions that distinguish it from standard Egyptological explanations.

- **Prediction 1 (Causeway Orientation):** If Giza encodes the Zep Tepi landscape, the Giza causeway orientation should correspond to the general direction of natural egress from the western side of the Richat ring system. The structural geometry of the Richat's ring system (Matton et al. 2005; Abdeina et al. 2024) should be consistent with the observed westward causeway orientation at Giza. A precise azimuth correspondence would constitute strong confirmation; qualitative directional agreement constitutes a weaker but still positive result.

- **Prediction 2 (Chamber Arrangement):** Quantitative analysis of the interior lies outside the scope of this paper, and the interpretation of the chamber arrangement is preliminary. The framework nonetheless generates a prediction that later work can test: if the interior carries the same cosmological grammar as the exterior, the three-chamber vertical arrangement (Subterranean, Queen's, King's) should correspond to the Zep Tepi sequence of water, threshold and transformation, and should do so consistently with the Pyramid Texts' description of the king's ascent. This prediction is recorded for completeness and is not quantitatively tested in the present paper.

- **Prediction 3 (Heit el-Ghurab aDNA):** Ancient DNA from the Giza workers' cemetery will show elevated North African Neolithic ancestry consistent with the Takarkori lineage (Salem et al. 2025). No aDNA has been published from Heit el-Ghurab at the time of writing.

- **Prediction 4 (Material Provenance — non-discriminating provenance control):** Geochemical sampling of Khufu-era casing stones will confirm local Egyptian limestone sources — consistent with symbolic (not material) encoding of Richat. Detection of Saharan material would not falsify the relational encoding claim, which concerns design and orientation, not stone origin.

- **Prediction 5 (New Discoveries):** If the Hawass corridor (once peer-reviewed) contains primary 4th Dynasty royal burial goods or Khufu's remains, the cosmological-encoding reading of that specific feature is weakened.

Failure of Predictions 1, 2, or 3 would require revision of the architectural encoding or demographic transmission claims. Prediction 4 is a null prediction; its success (local stone) is expected. Prediction 5 will be resolved by future peer-reviewed publication. Predictions 6 and 7 define prospective comparative tests for the mathematical encoding section: Prediction 6 tests whether domain-complete multi-domain encoding is distinctive to Giza across comparable monuments; Prediction 7 tests whether the three-layer Sirius-Osirian convergence is structurally unique in the comparative record. Prediction 8 records a unit-specificity test whose original single-target falsifier has been met.

Prediction 6 (Domain Completeness): A survey of comparable ancient monuments with published dimensions in native or proposed ancient units, run under declared rules (dimensions, operations, targets and tolerance fixed before scoring), will test whether any other single monument reaches the same combination of domains through its structural dimensions: (a) the four visible planetary synodic periods relevant to Old Kingdom astronomy — Saturn, Jupiter, Venus and Mars; and (b) the Sirius-Osirian calendar cluster — the 70-day invisibility period, the 360-day schematic administrative year and the 1,461-year Sothic cycle. The decision rule must treat the Sothic term identically for Giza and for every comparator: at the registered ±0.2% threshold Giza's own Sothic relation (0.240%) is a miss, so Giza is credited with the planetary quartet and the 70-day and 360-day relations, and not with a within-tolerance Sothic term.

Published work on other monuments describes other astronomical interpretations — Angkor Wat (Stencel, Gifford & Morón 1976; Mannikka 1996), Teotihuacan (Sugiyama 2010) and Stonehenge (Ruggles 1997; Cleal, Walker & Montague 1995) — but these studies are not formula-level surveys of this kind. Teotihuacan is the closest precedent: Sugiyama et al. (2021) report that Sugiyama's (2010) measurement-unit study interpreted the city's two major canals as being of symbolic and calendric significance. The 2010 chapter has not been read in full for this paper, so Teotihuacan is treated as a candidate for the survey, not as a completed comparison. Falsified by: identification of another monument whose structural dimensions, in its own native unit, reach the same combination under the same rules with comparable precision.

Prediction 7 (Sirius Three-Layer Structural Coherence): Three combinations of the Great Pyramid's exterior dimensions converge on the same celestial body and its associated ritual-calendar system across three distinct timescales: Height (280 cubits) × ¼ = 70 days — the canonical period of

Sirius's annual invisibility, encoded in Egyptian ritual as the duration of mummification and the death of Osiris; Half-base (220 cubits) + Height (280 cubits) × ½ = 360 days exactly — the schematic base of the civil calendar, the 12 × 30-day administrative year before the five epagomenal days are added (the 360-day layer encodes the schematic base of the Sirius-anchored civil calendar rather than a direct Sirius period; all three layers are unified through the Osirian calendar mythology); and Perimeter (1,760 cubits) × (½ + ¼ + 1⁄16 + 1⁄64) = 1,457.5 years, 0.240% from the 1,461-civil-year Sothic cycle governing the long-term recalibration — outside the ±0.2% threshold, and so not counted among the scored correspondences — between the civil calendar and Sirius's heliacal rising.

A prospective formula-level survey will test whether comparable monuments show an equivalent three-timescale pattern under declared rules. The cited studies describe other astronomical interpretations but do not constitute that survey. Because Giza's Sothic relation misses the registered ±0.2% threshold, this proposed pattern is not a completed three-hit result under the present scoring rule. Falsified by: identification of another ancient monument whose structural dimensions, in its own native unit, encode three independent correspondences converging on the same celestial body across three distinct timescales with comparable precision and coherence (the Giza Sothic term is itself a 0.240% miss).

Prediction 8 (Unit-System Specificity: initial falsifier met): The stated single-target prediction was that the anomalistic-month correspondence would not reproduce with equal precision in a non-cubit unit. That prediction is not sustained. With 0.5236 m per royal cubit and 0.9144 m per international yard, the base is 251.951 yards, and base × 7/64 = 27.5571, an error of 0.0114% against 27.554, compared with 0.1960% for 440 × 1/16 = 27.5. This does not imply ancient use of yards; it shows that this individual match is not cubit-specific. A saved check of the unchanged fourteen-target rule gives 10 targets in royal cubits, 6 in metres and 5 in international yards. The whole-list pattern remains a candidate for a future unit-specificity test, but it cannot retrospectively rescue the original single-target prediction; any successor test must specify its units, conversions, score and decision rule before new results are examined.

Prediction 9 — Testing the Construction Chronology of the Osiris Shaft

The proposed pre-monument origin of the Osiris Shaft, as a candidate for the pre-existing sanctuary the Westcar narrative portrays Khufu seeking to model (Westcar does not itself name the shaft), should be tested through a programme distinguishing primary cutting and construction from sarcophagus emplacement, reopening and later reuse. Surface-luminescence sampling of primary rock-cut walls is a candidate method, not an automatically valid carving clock: feasibility work must first establish a suitable mineral signal and demonstrate a resetting mechanism associated with excavation. Where feasible, depth-resolved measurements, sample-specific dosimetry and independently dated construction contexts should distinguish competing exposure and burial histories. Protected sarcophagus contact surfaces and securely associated construction interfaces should be investigated alongside wall surfaces. The existing sarcophagus results provide positive evidence for early surface histories, but constrain shaft construction only insofar as the dated events can be linked to installation in the present structure.

Contrary result: reproducible ages securely associated with primary construction of the proposed early sanctuary, demonstrably later than Khafre's causeway after accounting for chronological uncertainties, would contradict the pre-causeway interpretation of those elements. Dates of later repairs, enlargements or reopening would not by themselves date the first cutting. Failure to obtain a valid luminescence chronometer would be inconclusive, not evidence for either chronology.

Conclusion

The Great Pyramid of Giza is the most studied structure in human history. Every civilisation that encountered it asked the same question: what is this for?

This paper has proposed a different kind of answer. The pyramid is not primarily a tomb. It is the permanent architectural encoding of a cosmological system proposed to have developed within Green Sahara societies during the African Humid Period (which began approximately 14,500 years ago, as dated by Salem et al. 2025), was carried through a documented migration corridor, was transmitted through the Shemsu Hor, and was finally expressed at its definitive scale by the 4th Dynasty Egyptian state.

But the argument of this paper does not rest on that origin story alone. It rests on a set of empirical features — causeway orientations organised about the east–west axis (Nell & Ruggles 2014), a Giza layout diagonal that some authors relate to Heliopolis (Lehner 1985b; Magli 2010), integrated landscape planning (Lehner 1985), material-theological convergences (Shaw 2000; Belmonte et al. 2016), and 2000-year cultural continuity (Magli 2011) — that collectively constitute a constraint filter. To these the present analysis adds two results of a different character, in that each was constructed so that it could have failed. The sixty-fourths outperform their neighbouring grids at the Great Pyramid and at almost no other pyramid, against a random mean that is negative; and the reconstructed base of 440 stands near the top of its range for the documented Egyptian targets and in the middle of it for shadow targets of the same physical kind. Neither result demonstrates intent, which no arithmetical test can reach. Both narrow what else the dimensions could plausibly be. Any viable interpretation of Giza must account for these features simultaneously. The Zep Tepi model is consistent with the constraints assembled here.

The field is invited to propose alternative models that also pass through this constraint filter. Until such models are advanced, the Zep Tepi framework is offered as one candidate synthesis of these constraints; discrimination from an Egyptian-only cosmological account and from a combined funerary–cosmological account remains incomplete.

The pyramid was not built to last forever because it contained something valuable. It was built to last forever because it was something valuable — the permanent recreation of the First Time, the moment when the ancestors' world was whole, before the flood of sand took it away. As long as the pyramid stands, the Zep Tepi is not lost. The knowledge that generations of visitors sensed in the empty chambers was not concealed inside. It is the form they were standing within. The pyramid is not a container for knowledge. It is the knowledge, made stone.

The site was not called Giza in antiquity. That name is medieval Arabic. Later Egyptian sources associate it with Rostau — in the New Kingdom, “House of Osiris, Lord of Rostau” (Hawass 2007: 391) — and this paper takes “the West” (Imentet) as an interpretive motif; the only construction-era name securely attested is Akhet-Khufu. Read together, the western motif and the later Rostau designation express the interpretation advanced in this series. The western motif: the knowledge encoded here was carried from the west, along a documented corridor from the Green Sahara, across three thousand years of institutional memory. Rostau, read as its architectural destination: it was deposited at the entrance to an architectural system designed to translate that knowledge into permanent form — subterranean, cosmological, imperishable. The causeways point west. The chambers descend underground. The external dimensions encode the sky, the earth, and the long cycles of time. Akhet-Khufu supplies the construction-era name; the proposed Saharan origin and the reading of Rostau as its architectural destination remain this paper’s synthesis, not an explanation explicitly left by the builders.

The Osireion raises a question this paper cannot answer. Its dating is contested. Egyptological consensus attributes it to Seti I of the 19th Dynasty, on the cartouche in the approach corridor, quarry records from year six of his reign, and its shared axis with his temple (Frankfort, de Buck & Gunn 1933; Brand 2000). The evidence is more equivocal than that summary suggests. The cartouche occurs in the entrance passage; none of the main interior blocks carries any inscription, and Frankfort himself observed that the structure’s style does not match known work of Seti’s reign — an observation Petrie had already made of its archaic character. Two readings follow. Either Seti I

incorporated an existing structure into his complex, or he commissioned it deliberately in an archaic idiom in order to evoke older religious conceptions of water and rebirth. The second reading is the more economical, and it is the more consequential for the argument advanced here: deliberate archaism is not the absence of transmitted memory but its expression, a builder reaching for a grammar he knew to be ancient. A second position places the original structure in the Middle Kingdom, and it rests on physical dating rather than on textual attribution alone. Surface luminescence dating of Osireion samples by Liritzis and Vafiadou (2015) — the same study that dated the Osiris Shaft at Giza, cited above — returns Middle Kingdom ages for the granite together with a younger date for the sandstone, which the authors read as indicating original and later architectural phases. Strabo's identification of the builder as Ismandes (Geography XVII), conventionally read as Amenemhet III, is consistent with that reading, though Strabo himself writes with evident uncertainty and the structure's origins appear already to have been obscure in his day. On this account the Osireion is a two-phase monument: a Middle Kingdom original, restored and inscribed by Seti I some seven centuries later. On either account the builder was encoding the same Zep Tepi grammar that had been encoded at Giza, and knew what he was building. On the consensus dating the Osireion is itself evidence that the tradition survived the Second Intermediate Period, when Egyptian political unity was disrupted for over two centuries; on the minority dating it precedes that rupture, and the question becomes what carried the cosmological grammar through the silence between 1800 and 1550 BCE. Either way, when the tradition appears in the New Kingdom — in the stellar theology of the Amduat, in the Books of the Underworld, in the astronomical ceilings of the New Kingdom tombs — the question of what form it had taken, and what had been lost in the crossing, remains open.

These questions lie beyond the scope of this paper.

Why Proportion Rather Than Words

A question remains that the foregoing argument raises but does not answer. If a body of knowledge was to be preserved across the interval proposed here, why should it be committed to the proportions of a structure rather than to a record in words? The question is worth posing directly, because the answer bears on the form of the monument and not only on its content, and because the alternative was in principle available: the Fourth Dynasty possessed writing, and used it extensively in administration.

The difficulty with a verbal record is well characterised in the transmission literature already cited above. Oral tradition is subject to drift, and the rate of that drift is the central empirical question in the field. On the more restrictive estimates, transmission remains reasonably intact for only four or five generations before random change begins to accumulate. Against this, the Australian material assembled by Nunn and Reid (2016) documents traditions that have demonstrably preserved accurate coastal geography across some seven millennia, and the mechanism those authors and Kelly propose is specific: such traditions survive because they are anchored in landscape. Terrain is organised into a memory space, and the structure of the terrain constrains the structure of the account. The landscape does not drift, and so the tradition attached to it drifts more slowly than one which is not so attached.

The population proposed in this study had precisely that mechanism, and then lost the thing it depended on. The argument of the Corridor papers is that the Richat and its associated sites became progressively uninhabitable across the terminal African Humid Period, and that the population moved east. A community whose memory was anchored in a particular terrain, and which is leaving that terrain, faces a problem for which there are few solutions. One of them is to construct a new anchor rather than to inhabit an old one.

Proportion has a property in this connection which words do not, and it can be demonstrated from the Egyptian record itself rather than asserted. The Pyramid Texts have been continuously studied since the late nineteenth century, and individual utterances remain subject to competing translations: the same passage is rendered differently by Mercer, by Faulkner and by Allen, and the differences are not

trivial ones of style but of sense. This is the ordinary condition of an ancient text, and it is not a criticism of the philology. A dimensional relation is not subject to this kind of variation at all. The ratio of a height to a half-base does not have a disputed reading. It can be recovered by any observer able to measure the structure and perform a division, without a lexicon, without a grammar, and without a continuous tradition of interpretation. Recovering a geometric ratio does not by itself identify the intended unit, decoding operations or referent; the present hypothesis supplies those interpretive choices. Proportion may preserve a stable signal even when its intended message is no longer uniquely recoverable.

What follows from this is a statement about motive rather than about act, and the distinction should be kept sharp. The argument establishes that a community in the proposed circumstances would have had a reason to prefer an encoding in proportion to an encoding in words, and that the reason is a good one on the evidence of how transmission actually behaves. It does not establish that they did so. A sufficient motive is not a demonstration, and the alternative explanation of the monument's proportions — that they follow from the choice of a seked of five and a half palms and require no further account — remains available and is not refuted by anything in this section. What the section offers is an answer to the objection that the proposed encoding would have been a strange thing for anyone to attempt. On the transmission evidence, it would not have been strange. It would have been the obvious response of a people who had watched one anchor fail and were in a position to build another.

The Pyramid as Memory offers a testable answer to the question of what the pyramid is. What its bare chambers were for is the subject of **From Nun to the Stars**.

References

Zep Tepi Series — Prior Papers

Levy, S. (2026a). The Eye of the Sahara Hypothesis: A Predictive Model and 25-Element Testing Protocol for Predynastic Saharan Migration (Zep Tepi Series, Corridor I). Zenodo. DOI: 10.5281/zenodo.18472416

Levy, S. (2026b). Zep Tepi: People of the First Time Hypothesis: Saharan Cultural Memory and the Origins of Egyptian Sacred Symbolism (Zep Tepi Series, Corridor II). Zenodo. DOI: 10.5281/zenodo.19046277

Levy, S. (2026c). The Shemsu Hor Hypothesis: A Continuation — What Egypt Remembered (Zep Tepi Series, Corridor III). Zenodo. DOI: 10.5281/zenodo.19449606

Levy, S. (2026d). Phase Zero Hypothesis — The Bull in the Sky: Meskhetyu and the Shemsu Hor Path from Nabta Playa to the Giza Plateau (Zep Tepi Series, Bridging the Gap). Zenodo. DOI: 10.5281/zenodo.20150429

Levy, S. (2026e). The Sphinx Hypothesis: Master of the Key to the Lioness & She Who Restores the Wedjat (Zep Tepi Series, Supplementary to Corridor III). Zenodo. DOI: 10.5281/zenodo.20727853

Levy, S. (2026f). The Sekhmet-Heka Hypothesis: Magic, Medicine & Memory — Shemsu Hor Predynastic Encoding (Zep Tepi Series, Supplementary to Corridor III). Zenodo. DOI: 10.5281/zenodo.21466635

Levy, S. (2026h). From Nun to the Stars (Zep Tepi Series, The Destination, Paper II). Zenodo. DOI: 10.5281/zenodo.22903763

Primary Sources and Ancient Accounts

Al-Maqrizi. *Kitab al-Mawa'iz wa-al-I'tibar fi Dhikr al-Khitat wa-al-Athar ("Al-Khitat")*. c. 1400 CE. French translation: Bouriant, U. (1895–1900). *Description topographique et historique de l'Égypte*. Cairo: Mission archéologique Française.

Al-Masudi. *Akhbar al-Zaman* (History of Time). 10th century CE. Manuscript references in Fodor (1970) and al-Maqrizi.

Al-Masudi. *Meadows of Gold and Mines of Gems (Muruj al-Dhahab wa-Ma'adin al-Jawhar)*. c. 950 CE.

Diodorus Siculus. *Bibliotheca Historica*, Book I, Chapter 64. c. 60–30 BCE. Trans. Oldfather, C.H. (1933). Loeb Classical Library 279. Cambridge: Harvard University Press.

Edfu Building Texts. Ptolemaic era. Analysis: Reymond (Jelínková), E.A.E. (1960). The Mythological Origin of the Egyptian Temple. PhD thesis, University of Liverpool. https://livrepository.liverpool.ac.uk/3167399/

Herodotus. *Histories*, Book II, sections 124–128. Mid-fifth century BCE. Trans. Godley, A.D. (1920). Loeb Classical Library. Cambridge: Harvard University Press.

Ibn Wahshiyya. (10th century CE). *Kitab Shawq al-Mustaham fi Ma'rifat Rumuz al-Aqlam (Ancient Alphabets and Hieroglyphic Characters Explained)*. English translation: Hammer, J. von (1806). London: W. Bulmer & Co.

Merer. *Diary of Merer* (Wadi al-Jarf Papyri). c. 2560 BCE. Published: Tallet, P. (2017). *Les Papyrus de la Mer Rouge I*. IFAO, Cairo. English translation: Tallet, P. & Lehner, M. (2021). *The Red Sea Scrolls*. Thames & Hudson.

Plutarch. De Iside et Osiride. In: Moralia, Vol. V. Loeb Classical Library. Cambridge, MA: Harvard University Press. (Cited by Stephanus page: Moralia 359E.)

Pyramid Texts. c. 2400–2300 BCE. Trans. Allen, J.P. (2005). *The Ancient Egyptian Pyramid Texts*. Society of Biblical Literature. Atlanta.

Strabo. Geography, Book XVII. Loeb Classical Library. Cambridge, MA: Harvard University Press.

Medieval Arabic Sources and Historiography

Colavito, J. (2021). The Legends of the Pyramids: Myths and Misconceptions about Ancient Egypt. Bloomington: Red Lightning Books. ISBN 978-1-68435-148-0.

El-Daly, O. (2005). *Egyptology: The Missing Millennium: Ancient Egypt in Medieval Arabic Writings*. London: UCL Press.

Encyclopaedia of Islam, 2nd edition. (1960–2005). Brill. Entry: "al-Ma'mun" and "Pyramids."

Fodor, A. (1970). The Origins of the Arabic Legends of the Pyramids. *Acta Orientalia Academiae Scientiarum Hungaricae*, 23(3): 335–363.

Greaves, J. (1646). *Pyramidographia, or, A Description of the Pyramids in Ægypt*. London: George Badger.

Smith, M. (2007). Pyramids in the Medieval Islamic Landscape: Perceptions and Narratives. *Journal of the American Research Center in Egypt* 43: 1–14.

Ancient DNA and Population Genetics

Lipson, M., Ringbauer, H., Lucarini, G. et al. (2025). High continuity of forager ancestry in the Neolithic period of the eastern Maghreb.*Nature* 641: 925–931. DOI: 10.1038/s41586-025-08699-4.

Morez Jacobs, A. et al. (2025). Whole-genome ancestry of an Old Kingdom Egyptian. *Nature*, 644: 714–721. DOI: 10.1038/s41586-025-09195-5.

Salem, N. et al. (2025). Ancient DNA from the Green Sahara reveals ancestral North African lineage. *Nature* 641: 144–150. DOI: 10.1038/s41586-025-08793-7.

van de Loosdrecht, M. et al. (2018). Pleistocene North African genomes link Near Eastern and sub-Saharan African human populations. Science 360(6388): 548–552. DOI: 10.1126/science.aar8380.

Pyramid Construction and Logistics

Abou Zeid, S.M., Fekri, M.M. & Qandil, H.A. (2021). The Phyles System in Ancient Egypt. Journal of the Faculty of Tourism and Hotels — University of Sadat City 5(2): 210–219. DOI: 10.21608/mfth.2021.281765.

Gamal, M., Aly, S., Geeraerts, D., Hecht, A., Kouzes, R., Mahrouss, A., Mostafanezhad, I., Saftoiu, A., Stanca, D., Tytgat, M., Vancea, C., Valencia, J. & Wang, Z. (2025). The ScIDEP muon radiography project at the Egyptian Pyramid of Khafre. Journal of Applied Physics 138(4): 044901. DOI: 10.1063/5.0273135.

Ghoneim, E. et al. (2024). The Egyptian pyramid chain was built along the now abandoned Ahramat Nile Branch. *Communications Earth & Environment*. DOI: 10.1038/s43247-024-01379-7.

Lehner, M. (1997). The Complete Pyramids: Solving the Ancient Mysteries. London: Thames & Hudson. ISBN 978-0-500-28547-3.

Lehner, M. & Hawass, Z. (2017). *Giza and the Pyramids: The Definitive History*. University of Chicago Press.

Nuzzolo, M. (2015). The Bent Pyramid of Snefru at Dahshur: A project failure or an intentional architectural framework? Studien zur Altägyptischen Kultur 44: 259–282.

Sheisha, H. et al. (2022). Nile waterscapes facilitated the construction of the Giza pyramids during the 3rd millennium BCE. *PNAS* 119(37): e2202530119.

Van Neer, W., De Cupere, B. & Friedman, R.F. (2024). The earliest evidence for deformation of livestock horns: The case of Predynastic sheep from Hierakonpolis, Egypt. *Journal of Archaeological Science* 172: 106104. DOI: 10.1016/j.jas.2024.106104.

Van Neer, W., De Cupere, B. & Friedman, R.F. (2026). New archaeozoological analysis of baboons buried at Hierakonpolis (Upper Egypt) shows two species were imported in the Predynastic period.*Archaeological and Anthropological Sciences* 18: 62. DOI: 10.1007/s12520-026-02416-6.

Verner, M. (2001). *The Pyramids: The Mystery, Culture, and Science of Egypt's Great Monuments*. New York: Grove Press.

Younes, G., Marriner, N., Kaniewski, D., Sheisha, H. et al. (2024). The pyramid builders' waterways: Reconstructing the ancient topography of Khufu's Pharaonic Harbour at Giza, Egypt. *Journal of Archaeological Science: Reports* 53: 104303. DOI: 10.1016/j.jasrep.2023.104303.

Giza Archaeoastronomy and Site Planning

Belmonte, J.A. (2001). On the orientation of Old Kingdom Egyptian pyramids. *Archaeoastronomy* 26 (Supplement to Journal for the History of Astronomy 32): S1–S20.

Belmonte, J.A., Fekri, M., Abdel-Hadi, Y.A., Shaltout, M. & González-García, A.C. (2010). On the Orientation of Ancient Egyptian Temples: (5) Testing the Theory in Middle Egypt and Sudan. *Journal for the History of Astronomy* 41: 65–93. DOI: 10.1177/002182861004100103.

Belmonte, J.A. & Lull, J. (2023). *Astronomy of Ancient Egypt: A Cultural Perspective*. Historical & Cultural Astronomy. Cham: Springer. DOI: 10.1007/978-3-031-11829-6.

Belmonte, J.A., Pérez Die, M.C. & Díaz-Iglesias Llanos, L. (2016). Shrines of ram-headed divinities and Canopus: skyscaping at Herakleopolis Magna. *Mediterranean Archaeology and Archaeometry* 16(4): 125–132.

Belmonte, J.A. and Shaltout, M. (2010). Keeping Ma'at: an astronomical approach to the orientation of the temples in ancient Egypt. *Advances in Space Research* 46: 532–539.

Belmonte, J.A. and Magli, G. (2015). Astronomy, architecture, and symbolism: the global project of Sneferu at Dahshur. *Journal for the History of Astronomy* 46(2): 173–205. DOI: 10.1177/0021828615582356.

Belmonte, J.A., Shaltout, M. and Fekri, M. (2005). Astronomy and landscape in ancient Egypt: challenging the enigma of the minor step pyramids. *Trabajos de Egiptologia: Papers on Ancient Egypt* 4: 7–18.

Belmonte, J.A. (2009). The Egyptian calendar: keeping Ma'at on Earth. In: J.A. Belmonte and M. Shaltout (eds), In Search of Cosmic Order: Selected Essays on Egyptian Archaeoastronomy. Cairo: Supreme Council of Antiquities Press, pp. 75 ff.

Belmonte, J.A. (2011). In search of cosmic order: Astronomy and culture in Ancient Egypt. *Proceedings of the International Astronomical Union* 5(S260): 74–86. DOI: 10.1017/S174392131100216X.

Ćwiek, A. (1998). Date and function of the so-called minor Step Pyramids. *Göttinger Miszellen* 162: 39 –52.

Dreyer, G. & Kaiser, W. (1980). Zu den kleinen Stufenpyramiden Ober- und Mittelägyptens. *Mitteilungen des Deutschen Archäologischen Instituts, Abteilung Kairo* (MDAIK) 36: 43–59, plates 68–77.

Erdil, P., Webster, L., Kuitems, M., Knoblauch, C., Bestock, L., Höflmayer, F., Beeckman, H., Fuller, D.Q., Manning, S.W. & Dee, M.W. (2025). Resolution of the High versus Low debate for Old and Middle Kingdom Egypt. *PLOS ONE* 20(5): e0314612. DOI: 10.1371/journal.pone.0314612.

Goyon, G. (1969). La chaussée monumentale et le temple de la vallée de la pyramide de Khéops. Bulletin de l'Institut Français d'Archéologie Orientale 67: 49–69.

Janák, J., Vymazalová, H. & Coppens, F. (2011). The Fifth Dynasty 'sun temples' in a broader context. In: Abusir and Saqqara in the Year 2010 (conference proceedings): 430–442.

Jetsu, L. and Porceddu, S. (2015). 'Shifting Milestones of Natural Sciences: The Ancient Egyptian Discovery of Algol's Period Confirmed.' PLOS ONE 10(12): e0144140. DOI: 10.1371/journal.pone.0144140.

Jetsu, L., Porceddu, S., Lyytinen, J., Kajatkari, P., Lehtinen, J., Markkanen, T. and Toivari-Viitala, J. (2013). 'Did the Ancient Egyptians Record the Period of the Eclipsing Binary Algol—The Raging One?' The Astrophysical Journal 773(1): 1. DOI: 10.1088/0004-637X/773/1/1.

Joyanes-Díaz, L., Krejčí, J. and Muñoz González, C. (2025). The Sun as a phenomenon in the Old Kingdom architecture. In: J. Popielska-Grzybowska, J. Iwaszczuk, K. Kapiec and K.J. Radtke (eds), Egypt 2023: Perspectives of Research. Travaux de l'Institut des Cultures Méditerranéennes et Orientales de l'Académie Polonaise des Sciences 18. Warsaw–Wiesbaden: Harrassowitz, pp. 101 ff.

Lauer, J.-P. (1947). Le temple funéraire de Khéops à la grande pyramide de Guizeh. Annales du Service des Antiquités de l'Égypte 46: 245–259.

Lehner, M. (1985). The Development of the Giza Necropolis: The Khufu Project. *Mitteilungen des Deutschen Archäologischen Instituts, Abteilung Kairo* 41: 109–143.

Lehner, M. (1985b). A contextual approach to the Giza pyramids. Archiv für Orientforschung 31: 136–158.

Lull, J. & Belmonte, J.A. (2006). A firmament above Thebes: uncovering the constellations of ancient Egyptians. *Journal for the History of Astronomy* 37: 373–392. DOI: 10.1177/002182860603700401.

Lull, J. (2008). Meschetiu in der Mythologie und der Orientierung der ägyptischen Tempel. *Acta Praehistorica et Archaeologica* 40: 85–92.

Lyons, H. (1927). Ancient surveying instruments. The Geographical Journal 69(2): 132 ff.; cubit values on p. 135. DOI: 10.2307/1782725.

Magli, G. (2010). Topography, astronomy and dynastic history in the alignments of the pyramid fields of the Old Kingdom. *Mediterranean Archaeology and Archaeometry* 10(2): 59–74. Pre-print: arXiv:0903.1416v3.

Magli, G. (2011). Reconstruction of ancient conceptual landscapes in the Nile Valley. *Mediterranean Archaeology and Archaeometry* 11(2): 53–62. Pre-print: arXiv:1104.1785v1.

Magli, G. (2013). *Architecture, Astronomy and Sacred Landscape in Ancient Egypt*. Cambridge University Press.

Magli, G. (2016). The Giza 'written' landscape and the double project of King Khufu. *Time and Mind* 9(1): 57–74.

Magli, G. (2023). Satellite-Aided Analysis of the Position of the Sun Temples and the Dynastic History of the Vth Egyptian Dynasty. Heritage 6(11): 7156–7169. DOI: 10.3390/heritage6110374.

Magli, G. (2024). Cambodia and Java. In: Archaeoastronomy: Introduction to the Science of Stars and Stones. Cham: Springer, pp. 263–274. DOI: 10.1007/978-3-031-74960-5_13.

Marouard, G. & Papazian, H. (2012). The Edfu Pyramid Project: recent investigation at the last provincial step pyramid. *Oriental Institute News and Notes* 213: 3–9.

Nell, E. & Ruggles, C. (2014). The orientations of the Giza pyramids and associated structures. *Journal for the History of Astronomy* 45: 304–360. Pre-print: arXiv:1302.5622v2.

Petrie, W.M.F. (1883). *The Pyramids and Temples of Gizeh*. London: Field & Tuer.

Quibell, J.W. & Green, F.W. (1902). *Hierakonpolis. Part II*. London: Bernard Quaritch.

Shaltout, M. & Belmonte, J.A. (2005). On the Orientation of Ancient Egyptian Temples: (1) Upper Egypt and Lower Nubia. *Journal for the History of Astronomy* 36: 273–298.

Shaltout, M., Belmonte, J.A. and Fekri, M. (2007). ‘On the orientation of ancient Egyptian temples (3): key points in Lower Egypt and Siwa Oasis, Parts I and II.’ Journal for the History of Astronomy 38: 141 –160, 413–442.

Wong, J.Y. (2021). The role of environmental factors in the early development of Egyptian stone architecture. *Cambridge Archaeological Journal* 31(1): 53–65. DOI: 10.1017/S0959774320000232.

Richat Archaeology

Abdeina, E.H., Jourdan, F., Chazot, G., Bertrand, H. & Le Gall, B. (2024). How old is the Eye of Africa? A polyphase history for the igneous Richat Structure, Mauritania.*Lithos* 482–483: 107698. DOI: 10.1016/j.lithos.2024.107698.

Calvocoressi, D. & David, N. (1979). A new survey of radiocarbon and thermoluminescence dates for West Africa. Journal of African History 20(1): 1–29. DOI: 10.1017/S0021853700016698.

Giresse, P., Sao, O. & de Lumley, H. (2012). Étude paléoenvironnementale des sédiments quaternaires du Guelb er Richât (Adrar de Mauritanie) en regard des sites voisins ou associés du Paléolithique inférieur. Discussion et perspectives. *L’Anthropologie* 116(1): 12–38. DOI: 10.1016/j.anthro.2011.12.001

Matton, G., Jébrak, M. and Lee, J.K.W. (2005). ‘Resolving the Richat enigma: doming and hydrothermal karstification above an alkaline complex.’ Geology 33(8): 665–668. DOI: 10.1130/G21542AR.1.

Monod, T. (1975). Trois gisements préhistoriques dans la structure de Richat (Mauritanie). *Bulletin de l'Institut Fondamental d'Afrique Noire*, Série B, 37(3): 527–543.

Sao, O., Giresse, P., de Lumley, H., Faure, O., Perrenoud, C., Saos, T., Rachid, M.O. & Touré, O.C. (2008). Les environnements sédimentaires des gisements pré-acheuléens et acheuléens des wadis Akerdil et Bamouéré (Guelb er-Richât, Adrar, Mauritanie), une première approche. *L’Anthropologie* 112(1): 1–14. DOI: 10.1016/j.anthro.2008.01.001

Comparative Archaeology

Alexanian, N., Bebermeier, W., Blaschta, D., Ramisch, A., Schütt, B. & Seidlmayer, S.J. (2010). The Necropolis of Dahshur: Seventh Excavation Report. Cairo & Berlin: German Archaeological Institute / Free University of Berlin.

Cleal, R.M.J., Walker, K.E. & Montague, R. (1995). *Stonehenge in its Landscape: Twentieth-Century Excavations* (English Heritage Archaeological Report 10). London: English Heritage.

Dietrich, O., et al. (2012). The role of cult and feasting in the emergence of Neolithic communities: New evidence from Göbekli Tepe, Turkey. *Antiquity* 86(333): 674–695.

McNamara, L. (2008). The revetted mound at Hierakonpolis and early kingship: a reinterpretation. In Midant-Reynes, B. & Tristant, Y. (eds), Egypt at its Origins 2: Proceedings of the International Conference “Origin of the State: Predynastic and Early Dynastic Egypt”, Toulouse, 5th–8th September 2005. Orientalia Lovaniensia Analecta 172. Leuven: Peeters, pp. 901–936.

Friedman, R. (2009). Hierakonpolis Locality HK29A: the Predynastic ceremonial center revisited. Journal of the American Research Center in Egypt 45: 79–104.

Holl, A. (2009). Early West African Metallurgies: New Data and Old Orthodoxy. *Journal of World Prehistory* 22(4): 415–438.

Ruggles, C.L.N. (1997). Astronomy and Stonehenge. In: B. Cunliffe & C. Renfrew (eds.), *Science and Stonehenge* (Proceedings of the British Academy 92). Oxford: Oxford University Press for the British Academy, pp. 203–229.

Schmidt, K. (2006). *Sie bauten die ersten Tempel: Das rätselhafte Heiligtum der Steinzeitjäger*. Munich: C.H. Beck.

Verhoeven, M. (2024). Dividing the world, directing the mind: boundaries, art and ritual at Göbekli Tepe. In: B.S. Düring & J.-H. Plug (eds.), *The Archaeology of the 'Margins': Studies on Ancient West Asia in Honour of Peter M.M.G. Akkermans* (Analecta Praehistorica Leidensia 53). Leiden: Sidestone Press, pp. 219–234. DOI: 10.59641/h66998kt.

Wendorf, F. & Schild, R. (1998). *Nabta Playa and Its Role in Northeastern African Prehistory*. Journal of Anthropological Archaeology 17(2): 97–123.

19th Century Explorers and Tomb Robberies

Belzoni, G. (1820). *Narrative of the Operations and Recent Discoveries within the Pyramids, Temples, Tombs, and Excavations in Egypt and Nubia*. London: John Murray.

Peet, T.E. (1923). *The Rhind Mathematical Papyrus, British Museum 10057 and 10058: Introduction, Transcription, Translation and Commentary*. Liverpool: University Press of Liverpool; London: Hodder and Stoughton. (Reprint: Nendeln, Kraus Reprint, 1970.)

Peet, T.E. (1930). *The Great Tomb-Robberies of the Twentieth Egyptian Dynasty*. Oxford: Clarendon Press.

Vyse, H. (1840). *Operations Carried on at the Pyramids of Giza in 1837*. London: James Fraser.

Interior Scanning and New Discoveries

Hawass, Z.A. (2007). The Discovery of the Osiris Shaft at Giza. In: Z.A. Hawass & J. Richards (eds.), *The Archaeology and Art of Ancient Egypt: Essays in Honor of David B. O'Connor*, Vol. I. Annales du Service des Antiquités de l'Égypte, Cahier 36. Cairo: Supreme Council of Antiquities, pp. 379–397.

Helal, K., Pugacheva, P., Allam, H. et al. (2025). Detection of two anomalies behind the Eastern face of the Menkaure Pyramid using a combination of non-destructive testing techniques. *NDT & E International* 155: 103331. DOI: 10.1016/j.ndteint.2025.103331.

Liritzis, I. & Vafiadou, A. (2015). Surface luminescence dating of some Egyptian monuments. *Journal of Cultural Heritage* 16(2): 134–150. DOI: 10.1016/j.culher.2014.05.007.

Morishima, K. et al. (2017). Discovery of a big void in Khufu's Pyramid by observation of cosmic-ray muons. *Nature* 552: 386–390.

Procureur, S. et al. (2023). Precise characterisation of the ScanPyramids North Face Corridor. *Nature Communications* 14: 1144.

Pugacheva, P. et al. (2025). Investigation of the North Face Corridor using Electrical Resistivity Tomography. *Scientific Reports* 15: 41187. DOI: 10.1038/s41598-025-29081-4.

Rosell Roig, V.L. (2026). A computational framework for evaluating an edge-integrated, multi-ramp construction model of the Great Pyramid of Giza. *npj Heritage Science* 14: 142. DOI: 10.1038/s40494-026-02405-x.

Scheuring, S.A. (2025). Construction of the Great Pyramid with pulley-like systems using counter-weights on sliding-ramps. npj Heritage Science 13: 473. DOI: 10.1038/s40494-025-02018-w.

Schumacher, T. et al. (2025). Confirmation of the ScanPyramids North Face Corridor using multi-modal image fusion. *Scientific Reports* 15: 9275. DOI: 10.1038/s41598-025-91115-8.

Stadelmann, R. (1991). *Die ägyptischen Pyramiden: Vom Ziegelbau zum Weltwunder*. 2., überarbeitete und erweiterte Auflage. Mainz: Philipp von Zabern.

Egyptian Cosmology and the Benben

Allen, J.P. (2005). *The Ancient Egyptian Pyramid Texts*. Society of Biblical Literature. Atlanta.

Allen, J.P. (2015). The Ancient Egyptian Pyramid Texts, 2nd edition. Writings from the Ancient World 38. Atlanta: SBL Press, 394 pp. [The current standard translation and this series' reference edition. Source of the account of the Pyramid Texts' editorial history (p. 4) and of PT 600 (p. 265).]

Andrews, C. (1994). Amulets of Ancient Egypt. London: British Museum Press.

Brand, P.J. (2000). The Monuments of Seti I: Epigraphic, Historical and Art Historical Analysis. Probleme der Ägyptologie 16. Leiden: Brill, pp. 174–178. ISBN 978-90-04-11770-9.

Britannica, The Editors of Encyclopaedia. "Elephantine." *Encyclopedia Britannica*, 31 Oct. 2023.

Frankfort, H., de Buck, A. & Gunn, B. (1933). The Cenotaph of Seti I at Abydos, 2 vols. Egypt Exploration Society Memoir 39. London: Egypt Exploration Society.

Hornung, E. (1996). *Conceptions of God in Ancient Egypt*. Cornell University Press.

Hornung, E. (1999). *The Ancient Egyptian Books of the Afterlife*. Trans. D. Lorton. Ithaca: Cornell University Press.

Kroft, S.E. (2024). Exploring the Expression of Time and Memory in Decorated Ware Vessel Compositions through Experimental Archaeology. In: Current Research in Egyptology 2024, pp. 184–195. Oxford: Archaeopress. DOI: 10.32028/9781805831136.

Malville, J.M., Schild, R., Wendorf, F. & Brenmer, R. (2008). Astronomy of Nabta Playa. In: Holbrook, J., Medupe, R. & Urama, J. (eds), *African Cultural Astronomy*. Springer, New York, pp. 131–143.

Sherkova, T.A. (2023). Eye Painting Ritual, Bull Sacrifice and the Myth of the Eye of Horus in Ancient Egypt [in Russian]. Bulletin of Science and Practice 9(4): 535–558. DOI: 10.33619/2414-2948/89/71.

Wilkinson, R.H. (2001). *The Complete Gods and Goddesses of Ancient Egypt*. Thames & Hudson, London.

Winkler, A. (2021). Stellar scientists: the Egyptian temple astrologers. Journal of Ancient Near Eastern History 8(1–2): 91–145.

Star Shafts

Badawy, A. (1964). The stellar destiny of pharaoh and the so-called air-shafts of Cheops's pyramid. *Mitteilungen des Instituts für Orientforschung* 10(2/3): 189–206.

Bauval, R. & Gilbert, A. (1994). *The Orion Mystery: Unlocking the Secrets of the Pyramids*. London: William Heinemann.

Damiani, P. (1991). La grande pyramide : observatoire astronomique. Journal de la Société de Statistique de Paris 132(3): 93–106.

Dash, G. (2012). New angles on the Great Pyramid. *AERAgram* 13(2) (Fall 2012). Ancient Egypt Research Associates.

Dash, G. (2017). Occam's Egyptian razor: the equinox and the alignment of the pyramids. *Journal of Ancient Egyptian Architecture* 2: 1–8.

de Trafford, A. (2005). Exploring the contextual and symbolic relationships between mummies and texts in Late Old Kingdom pyramids. Journal of Biological Research 80(1): 184–187. DOI: 10.4081/jbr.2005.10179.

Nemes, G.W. (2020). The mythological importance of the constellation Msḫtjw in mortuary representations until the end of the New Kingdom. ENiM 13: 1–61.

Neugebauer, O. & Parker, R.A. (1969). *Egyptian Astronomical Texts, Vol. III: Decans, Planets, Constellations and Zodiacs*. Providence: Brown University Press; London: Lund Humphries.

Parker, R.A. (1950). *The Calendars of Ancient Egypt* (Studies in Ancient Oriental Civilization 26). Chicago: University of Chicago Press.

Pochan, A. (1971). L'énigme de la grande pyramide. Paris: Robert Laffont.

Rawlins, D. & Pickering, K. (2001). Astronomical orientation of the pyramids. *Nature* 412: 699. DOI: 10.1038/35089138

Schaefer, B.E. (1998). To the visual limits. Sky & Telescope 95(5): 57–60.

Spence, K. (2000). Ancient Egyptian chronology and the astronomical orientation of pyramids. *Nature* 408: 320–324.

Trimble, V. (1964). Astronomical investigation concerning the so-called air-shafts of Cheops's pyramid. *Mitteilungen des Instituts für Orientforschung* 10(2/3): 183–187.

Vondrák, J., Capitaine, N. & Wallace, P. (2011). New precession expressions, valid for long time intervals. Astronomy & Astrophysics 534: A22. DOI: 10.1051/0004-6361/201117274.

Mathematical Encoding and Metrology

Clagett, M. (1999). *Ancient Egyptian Science, Vol. III: Ancient Egyptian Mathematics* (Memoirs of the American Philosophical Society 232). Philadelphia: American Philosophical Society.

Douady, S. & Couder, Y. (1992). Phyllotaxis as a physical self-organized growth process. *Physical Review Letters* 68(13): 2098–2101. DOI: 10.1103/PhysRevLett.68.2098.

Gardiner, A.H. (1927). *Egyptian Grammar: Being an Introduction to the Study of Hieroglyphs*. Oxford: Clarendon Press.

Gillings, R.J. (1972). *Mathematics in the Time of the Pharaohs*. Cambridge, MA: MIT Press.

Herz-Fischler, R. (2000). *The Shape of the Great Pyramid*. Waterloo, Ontario: Wilfrid Laurier University Press.

Imhausen, A. (2006). Ancient Egyptian mathematics: New perspectives on old sources. *The Mathematical Intelligencer* 28(1): 19–27. DOI: 10.1007/BF02986998.

Möller, G. (1911). Die Zeichen für die Bruchteile des Hohlmaßes und das Uzatauge. *Zeitschrift für Ägyptische Sprache und Altertumskunde* 48: 99–101.

Okabe, T. (2015). Biophysical optimality of the golden angle in phyllotaxis. *Scientific Reports* 5: 15358. DOI: 10.1038/srep15358.

Pommerening, T. (2003). Altägyptische Rezepturen metrologisch neu interpretiert. *Berichte zur Wissenschaftsgeschichte* 26: 1–16.

Poole, R.S. (1851). Horae Aegypticae: or, the Chronology of Ancient Egypt, discovered from astronomical and hieroglyphic records upon its monuments. London: Longman, Brown, Green & Longmans. Digitised edition: Heidelberg University Library. DOI: 10.11588/diglit.12654.

Posener-Kriéger, P. (1994). Les mesures de grain dans les papyrus de Gébélein. In C. Eyre, A. Leahy and L. Montagno Leahy (eds.), The Unbroken Reed: Studies in the Culture and Heritage of Ancient Egypt in Honour of A.F. Shore (EES Occasional Publications 11), pp. 269–272. London: Egypt Exploration Society.

Richardson, R., Whitehead, S., Ng, T.C., Hawass, Z., Pickering, A., Rhodes, S., Grieve, R., Hildred, A., Nagendran, A., Liu, J., Mayfield, W., Tayoubi, M. and Breitner, R. (2013). The "Djedi" robot exploration of the southern shaft of the Queen's Chamber in the Great Pyramid of Giza, Egypt. Journal of Field Robotics 30(3): 323–348. DOI: 10.1002/rob.21451.

Ritter, J. (2002). Closing the Eye of Horus: The Rise and Fall of 'Horus-eye Fractions'. In: J.M. Steele & A. Imhausen (eds.), *Under One Sky: Astronomy and Mathematics in the Ancient Near East* (Alter Orient und Altes Testament 297). Münster: Ugarit-Verlag, pp. 297–323.

Robins, G. & Shute, C. (1987). *The Rhind Mathematical Papyrus: An Ancient Egyptian Text*. London: British Museum Publications.

Rossi, C. (2003). Architecture and Mathematics in Ancient Egypt. Cambridge: Cambridge University Press. Corrected reprint, 2006.

Tallet, P. (2017). Les papyrus de la mer Rouge I: Le « journal de Merer » (Papyrus Jarf A et B). MIFAO 136. Cairo: Institut français d'archéologie orientale.

Zapassky, E., Gadot, Y., Finkelstein, I. & Benenson, I. (2012). An ancient relation between units of length and volume based on a sphere. PLoS ONE 7(3): e33895. DOI: 10.1371/journal.pone.0033895.

Abusir Papyri

Posener-Kriéger, P. (1976). *Les archives du temple funéraire de Néferirkarê-Kakaï*. Cairo: IFAO.

Cultural Memory

Assmann, J. (1995). Collective Memory and Cultural Identity. *New German Critique*, 65, 125–133.

Assmann, J. (2001). *The Search for God in Ancient Egypt*. Cornell University Press.

Assmann, J. (2005). Death and Salvation in Ancient Egypt. Trans. David Lorton. Ithaca: Cornell University Press.

Barber, E.W. and Barber, P.T. (2004). When They Severed Earth from Sky: How the Human Mind Shapes Myth. Princeton: Princeton University Press.

Edwards, I.E.S. (1986). The Shetayet of Rosetau. In: L.H. Lesko (ed.), *Egyptological Studies in Honor of Richard A. Parker: Presented on the Occasion of His 78th Birthday, December 10, 1983*. Hanover, NH: University Press of New England, pp. 27–36.

Hamacher, D.W. (2018). 'Observations of red-giant variable stars by Aboriginal Australians.' The Australian Journal of Anthropology 29(1): 89–107. DOI: 10.1111/taja.12257.

Kelly, L. (2015). Knowledge and Power in Prehistoric Societies: Orality, Memory, and the Transmission of Culture. Cambridge: Cambridge University Press.

Mannikka, E. (1996). *Angkor Wat: Time, Space, and Kingship*. Honolulu: University of Hawai'i Press.

Morales, A.J. (2016). Text-building and Transmission of Pyramid Texts in the Third Millennium BCE: Iteration, Objectification, and Change. Journal of Ancient Near Eastern Religions, 15(2): 169–201. DOI: 10.1163/15692124-12341273.

Nunn, P.D. & Reid, N.J. (2016). Aboriginal memories of inundation of the Australian coast dating from more than 7000 years ago. Australian Geographer 47(1): 11–47. DOI: 10.1080/00049182.2015.1077539.

Olabarria, L. (2020). Coming to terms with stelae: a performative approach to memorial stelae and chapels of Abydos in the Middle Kingdom. Studien zur altägyptischen Kultur 49. (Page cited from the peer-reviewed accepted manuscript, University of Birmingham.)

Romain, W.F. (2022). Angkor Wat. Journal of Skyscape Archaeology 8(1): 4–35. DOI: 10.1558/jsa.19967.

Rubin, D.C. (1995). Memory in Oral Traditions: The Cognitive Psychology of Epic, Ballads, and Counting-Out Rhymes. New York: Oxford University Press.

Stencel, R., Gifford, F. and Morón, E. (1976). Astronomy and cosmology at Angkor Wat. Science 193(4250): 281–287. DOI: 10.1126/science.193.4250.281.

Sugiyama, N., Sugiyama, S., Catignani, T., Chase, A.S.Z. and Fernandez-Diaz, J.C. (2021). Humans as geomorphic agents: Lidar detection of the past, present and future of the Teotihuacan Valley, Mexico. PLOS ONE 16(9): e0257550. DOI: 10.1371/journal.pone.0257550.

Sugiyama, S. (2010). Teotihuacan City Layout as a Cosmogram: Preliminary Results of the 2007 Measurement Unit Study. In: I. Morley & C. Renfrew (eds.), *The Archaeology of Measurement: Comprehending Heaven, Earth and Time in Ancient Societies*. Cambridge: Cambridge University Press, pp. 130–149.

Vansina, J.M. (1985). Oral Tradition as History. Madison: University of Wisconsin Press.

Zago, S. (2022). A Journey through the Beyond: The Development of the Concept of Duat and Related Cosmological Notions in Egyptian Funerary Literature. Lockwood Press. ISBN 978-1-9484-8853-2.

Methodological Note

Whewell, W. (1840). The Philosophy of the Inductive Sciences, Founded Upon Their History. London: John W. Parker. (Consilience of inductions framework cited for cumulative probabilistic convergence methodology.)

Westcar Papyrus and Manetho

Blackman, A.M. (1988). *The Story of King Kheops and the Magicians: Transcribed from Papyrus Westcar (Berlin Papyrus 3033)*. Edited by W.V. Davies. Reading: J.V. Books.

Breasted, J.H. (1912). *Development of Religion and Thought in Ancient Egypt*. New York: Charles Scribner's Sons.

Manetho (3rd century BCE). *Aegyptiaca*. Translated by W.G. Waddell (1940). Loeb Classical Library 350. Cambridge: Harvard University Press.

Parkinson, R.B. (1997). *The Tale of Sinuhe and Other Ancient Egyptian Poems, 1940–1640 BC*. Oxford: Clarendon Press.

Saqqara Dry Moat

Jeffreys, D. (2010). The Great Dry Moat of Saqqara. In: *Egyptian Archaeology* 37: 12–14.

Landreau, X., Piton, G., Morin, G., Bartout, P., Touchart, L., Giraud, C., Barre, J.-C., Guerin, C., Alibert, A. & Lallemand, C. (2024). On the possible use of hydraulic force to assist with building the step pyramid of Saqqara. PLOS ONE 19(8): e0306690. DOI: 10.1371/journal.pone.0306690.

Lauer, J.P. (1936). *La Pyramide à Degrés: L'Architecture*. Cairo: IFAO.

Welc, F., Mieszkowski, R., Trzciński, J. & Kowalczyk, S. (2015). Western Section of the 'Dry Moat' Channel Surrounding Step Pyramid Complex in Saqqara in the Light of Ground-penetrating Radar Prospection. Archaeological Prospection 22(4): 293–305. DOI: 10.1002/arp.1514.

African Impact Structures

Koeberl, C. et al. (1998). The Aouelloul crater, Mauritania: On the problem of confirming the impact origin of a small crater. *Meteoritics & Planetary Science* 33(3): 513–517.

Koeberl, C., Reimold, W.U., Cooper, G., Cowan, D. & Vincent, P.M. (2005). Aorounga and Gweni Fada impact structures, Chad: Remote sensing, petrography, and geochemistry of target rocks. *Meteoritics & Planetary Science* 40(9–10): 1455–1471. DOI: 10.1111/j.1945-5100.2005.tb00412.x

Lamali, A., Rochette, P., Merabet, N. et al. (2016). Geophysical and magneto-structural study of the Maâdna structure (Talemzane, Algeria): Insights on its age and origin. *Meteoritics & Planetary Science* 51: 2249 ff. DOI: 10.1111/maps.12715

Lambert, P., McHone, J.F., Dietz, R.S. & Houfani, M. (1980). Impact and impact-like structures in Algeria, Part I, Four bowl-shaped depressions. *Meteoritics* 15: 157–179.

Reimold, W.U. & Koeberl, C. (2014). Impact structures in Africa: A review. *Journal of African Earth Sciences* 93: 57–175. DOI: 10.1016/j.jafrearsci.2014.01.008

Schultze, D.S., Jourdan, F., Hecht, L., Reimold, W.U. & Schmitt, R.-T. (2016). Tenoumer impact crater, Mauritania: Impact melt genesis from a lithologically diverse target. *Meteoritics & Planetary Science* 51(2): 323–350. DOI: 10.1111/maps.12593

Sighinolfi, G.P., Barbieri, M., Brunelli, D. & Serra, R. (2020). Mineralogical and chemical investigations of the Amguid crater (Algeria): Is there evidence of an impact origin? *Geosciences* 10(3): 107. DOI: 10.3390/geosciences10030107

van Gasselt, S., Kim, J.R., Choi, Y.-S. & Kim, J. (2017). The Oasis impact structure, Libya: Geological characteristics from ALOS PALSAR-2 data interpretation. *Earth, Planets and Space* 69: 35. DOI: 10.1186/s40623-017-0620-8

Chronology

Dee, M., Wengrow, D., Shortland, A., Stevenson, A., Brock, F., Girdland Flink, L. & Bronk Ramsey, C. (2013). An absolute chronology for early Egypt using radiocarbon dating and Bayesian statistical modelling. Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences 469(2159): 20130395. DOI: 10.1098/rspa.2013.0395.

Shaw, I. (2000). *The Oxford History of Ancient Egypt*. Oxford University Press.

Saharan Palaeoenvironment

Kuper, R. & Kröpelin, S. (2006). Climate-controlled Holocene occupation in the Sahara: motor of Africa's evolution. Science 313(5788): 803–807. DOI: 10.1126/science.1130989.

Trauth, M.H., Asrat, A., Fischer, M.L. et al. (2024). Early warning signals of the termination of the African Humid Period(s). *Nature Communications* 15: 3697. DOI: 10.1038/s41467-024-47921-1.

Non-Peer-Reviewed Sources

Egypt Independent (November 9, 2025). "Zahi Hawas announces discovery of 30-meter corridor inside Great Pyramid of Khufu." Cairo.

Egyptian Ministry of Tourism and Antiquities (2025). Italian archaeological mission in Abu Ghurab unearths remains of the Valley Temple of King Nyuserre Ini. Announcement of 12 December 2025. Cairo: Supreme Council of Antiquities / State Information Service.

Lluch, P. & Philip, S. (2003). Six stations à gravures du N.E. de l'Adrar (dhar Chinguetti, Mauritanie). Cahiers de l'AARS 8: 87–96. [Cahiers de l'AARS: submissions pass a comite de lecture, but the imprint states that articles are published under the sole responsibility of the authors and no review procedure is described. Cited for the Tililit rock art.]

Ministero degli Affari Esteri e della Cooperazione Internazionale (2026). Egypt — A new sun temple discovered at the site of Abu Ghurab. Rome: Italian Ministry of Foreign Affairs and International Cooperation.

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No AI tool generated the published archaeological, textual or astronomical evidence cited here; all cited evidence derives from published sources. The computational analyses reported here were carried out with AI-assisted scripting and checking, and their results should be read on that footing. The interpretive framework, hypothesis structure, and editorial judgments are the author's own. AI-generated citations were found during preparation to contain errors of title, venue, volume and authorship, including references to works that do not exist; the author regards independent verification of AI-assisted citation as a necessary step rather than an optional one. Verification in this paper varied in depth, from inspection of original pages to bibliographic-record and abstract checks, and a record check does not verify every claim for which a work is cited.

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